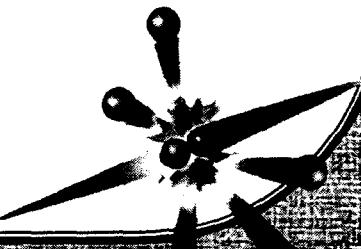


# **The U.S. HEP Program A Global Viewpoint and How is SLAC Positioned to Play Its Part**

**by  
Jonathan Dorfan  
Director, SLAC**

**Presentation at the FNAL Users Meeting**

**26 June, 2000**

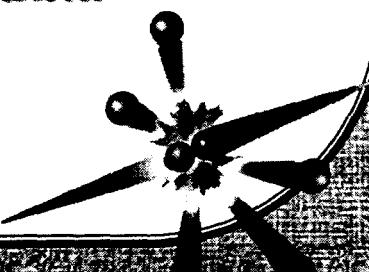


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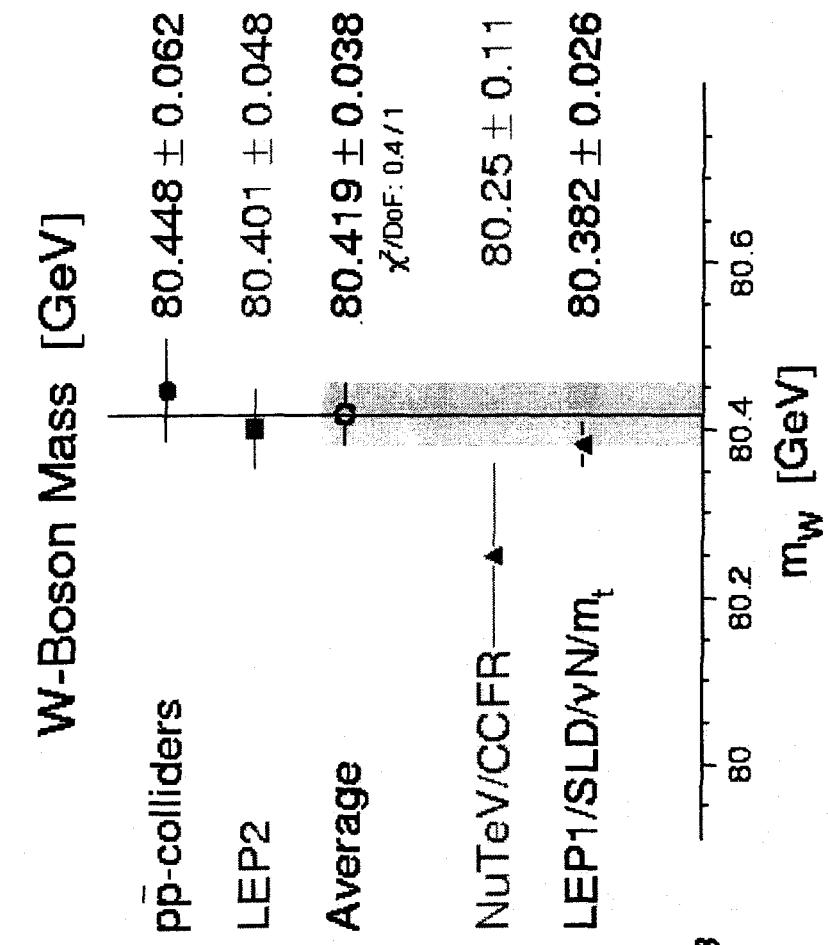
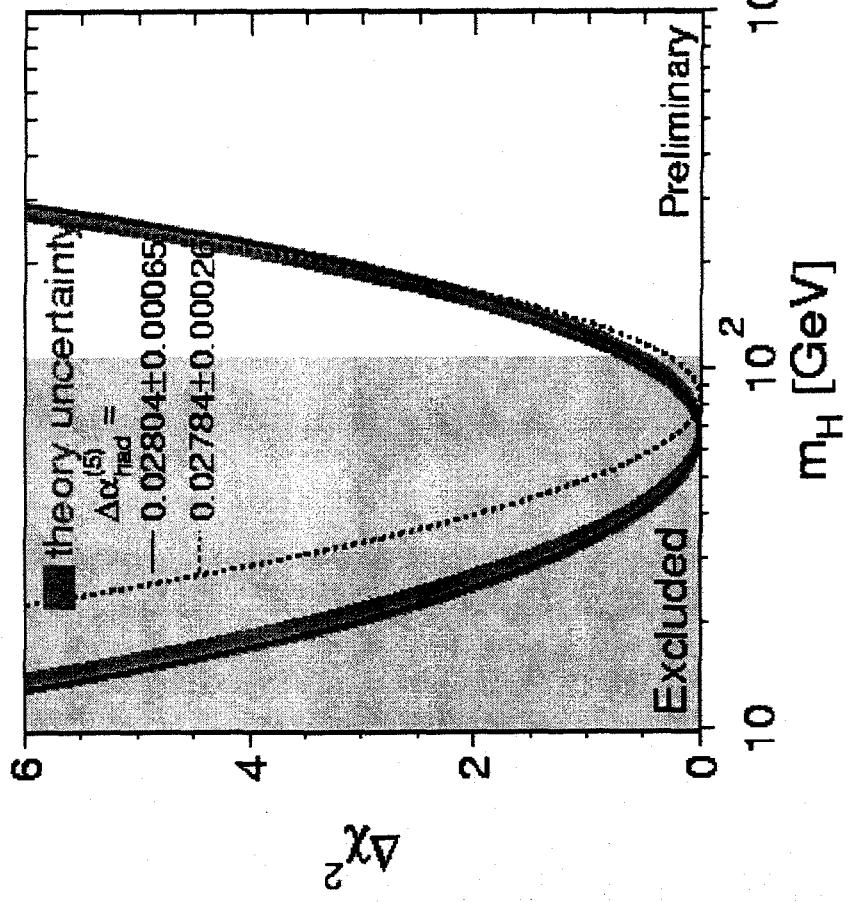
# The Next Five Years Prospects for Data

- Combination of data of the last 10 years from proton and electron machines provide tantalizingly powerful constraints on the SM and its extensions, in particular with regard to the crucial issue of electro-weak Symmetry breaking
  - ↳ Main Injector significantly extends the reach for Higgs and SUSY searches. CDF and DO provide exciting discovery potential
- Two asymmetric *B* Factories - KEK / Belle and PEP-II/BABAR - are working very well. We are on the brink of the next major advance in answering the critical question of the origin of CP Violation and its relationship to electro-weak Baryogenesis.

Along with the upgrade CESR / CLEO, we can anticipate a new level of precision in the study of heavy flavors. In the next 5 years, we could have 10-100 times the statistics of present data



# LEP Electro-weak Working Group



# Data Prospects

## (Continued)

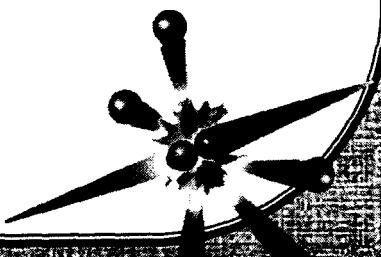
- Recent oscillation data indicate that neutrinos have mass - this opens up a new horizon of important questions
  - ↳ Mini Boone and Numi / Minos are key elements of the next level of understanding

**We will need more powerful proton sources to answer all the critical questions**

**Majorana or Dirac? How to measure masses, as opposed to mass differences?**

- Neutrinoless double beta decay offer exciting possibilities
- We are entering a most exciting era for new data. The US program provides the bulk of the strength of the accelerator-based programs of the next 5 years
  - ↳ Crucial that we maximize the physics output. This demands aggressive utilization, expeditious implementation of in-construction facilities

**Must make the physics case persuasively to Administration and Congress. We are significantly under-funded given our exciting prospects**



## SLAC HEP Experimenters / Users - March 2000

Total - 1257

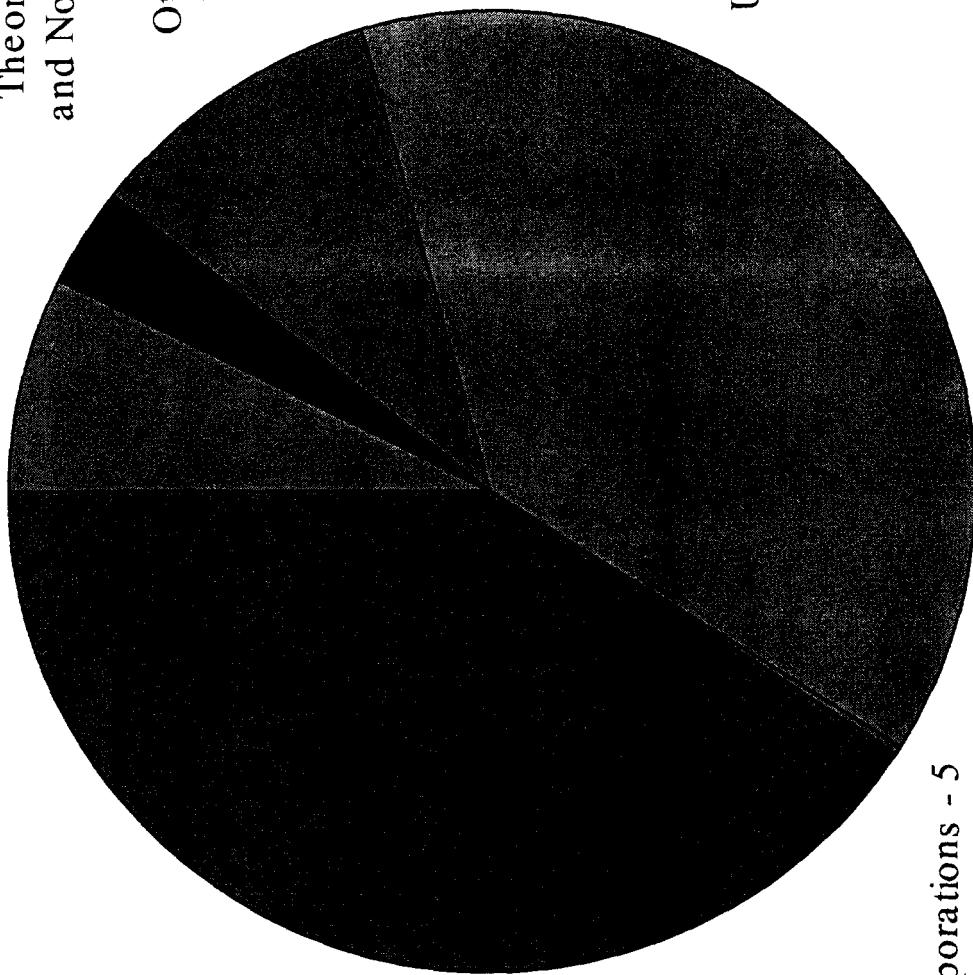
Non SLAC - 1123

SLAC Staff  
Experimenters - 92

Theorists - SLAC  
and Non-SLAC - 42

Other Govt/Lab  
Users - 124

Foreign Users - 512

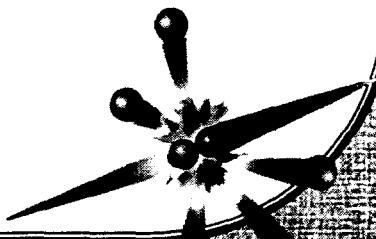


# The Next 5 years Data from SLAC

- **Electro-weak Physics**

- The SLD program is in its final analysis stage. Results in the electro-weak (and QCD) sector are competitive with LEPI. Can anticipate improved precision in  $A_b$  and  $B_s$  mixing soon
- End Station A fixed target program moves away from the definitive studies on the nucleon spin crisis to a high precision Möller scattering experiment which will measure  $\sin^2\theta_w$  at low  $q^2$ . Does  $\sin^2\theta_w$  run as predicted by SM?

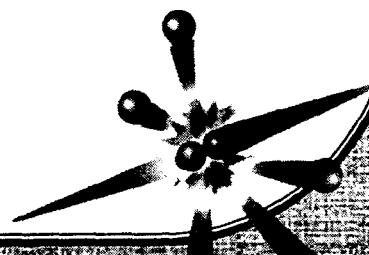
A 4 month run - split between FY01 and FY02 - will provide ample statistics to measure this effect



# SLD Results and Plans

- A number of new results, most based on the complete 1992-98 sample and some of which are final, will be presented this summer at ICHEP 2000 in Osaka
- The final  $A_{LR}$  and  $A_{\text{lepton}}$  measurements
  - The SLD measurement of  $\sin^2 \theta_W^{\text{eff}}$  sets the World standard, with much smaller systematic error than any other technique
- Updated heavy flavor NC couplings
  - The SLD measurements of b- and c-quark couplings are uniquely precise and direct
- Updated  $B_s$  mixing measurements
  - Powerful techniques will enable the SLD to provide the best available limits by ICHEP 2000
- A total of 20 abstracts (electroweak, heavy flavor and QCD) have been submitted

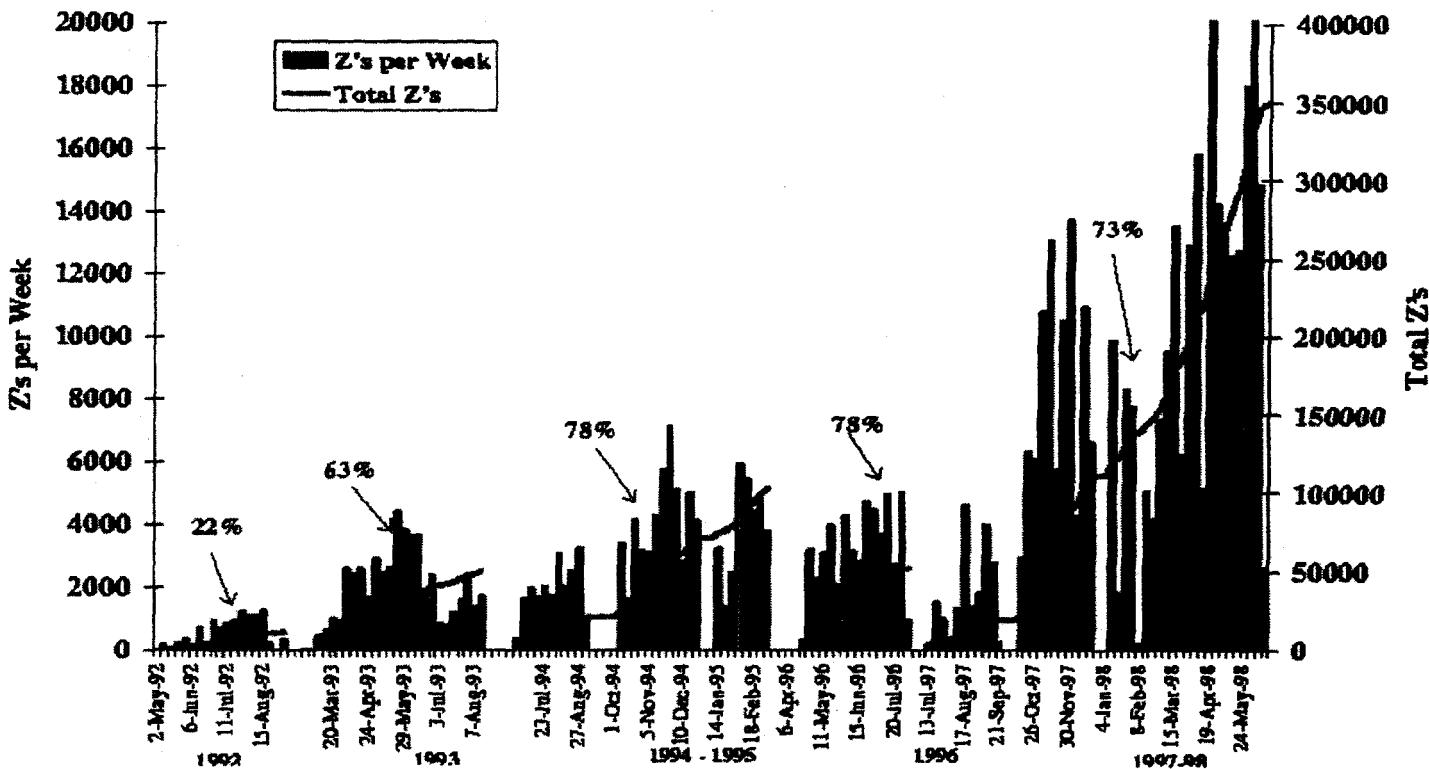
SLD data analysis activities are planned for at least another year (3 postdocs, 10 students)



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# The SLD Program at the SLC

- Complements that at the LEP collider at CERN
- Single pass collider at  $E_{cm} \approx M_Z$
- 550k hadronic events delivered over 6.1 years



- Highly longitudinally polarized electron beam
- Very small transverse collision region  
 $0.8 \times 1.8 \times 650 \mu\text{m}$   
vertical      horizontal      along beam
- The SLD detector features excellent  
vertex detection: VXD3, 3M pixels on CCDs  
hadron identification: dual-radiator CRID
- Small, focussed collaboration

# SLD Physics Results

## I) Unique or world-best measurements:

- $A_{LR}$       Final results:       $A_e = 0.1514 \pm 0.0022$        $\sin^2 \theta_W^{\text{eff}} = 0.23097 \pm 0.00027$ ♦  
PRL:70,2515; 73,25; 78,2075; final submitted. PRD in prep.
- $A_e, A_\mu, A_\tau$       Improved:  $A_{\text{lepton}} = 0.1519 \pm 0.0052$ ♦  
PRL:74,2880; 78,17; 79,8045. SLAC-Pub-8213
- $A_b$ ♦  
4 techniques, 2 unique to SLD, 3 self-calibrating  
PRL:74,2890; 81,942; 83,1902. SLAC-Pub-8200,8201,8211
- $A_c$       5 techniques, 2 unique&self-calibrating♦  
PRL:74,2895; 75,3609; 83,3384. PRD sub'd. SPub-7879,8199
- $A_s$       Final; unique method, partly self-calib.♦  
PRL in prep. SLAC-Pub-8154
- $R_c$       Unique, fully self-calibrating method  
SLAC-Pub-7880
- New Tests of P-, CP-, T-violation  
Using decays of polarized  $Z^0 \rightarrow 3$  hadronic jets  
PRL 75,4173, final in prep. SLAC-Pub-8156
- Structure of 3-jet events      First over full-kin.-range,  
limits on anomalous chromomagnetic moments  
PRD 60,92002. SLAC-Pub-8155

## $A_{\text{lepton}}$ , $\sin^2 \theta_w^{\text{eff}}$ and the Higgs mass

- The  $A_{\text{lepton}}$  are very sensitive to the effective weak mixing angle, which depends logarithmically on the mass of the Higgs boson
- Our  $A_{LR}$  measurement is now final
- The relative systematic error is 0.65%, dominated by polarimeter linearity
- Polarimeter scale verified to 0.3% and 0.5% by two independent polarimeters
- Dedicated experiment verified the positron polarization  $P_{e^+} = -0.0002 \pm 0.0007$  to be consistent with zero
- Dedicated runs verified the c.m. energy and other corrections to 0.1%
- The result remains statistics dominated:

$$A_e = 0.1514 \pm 0.0019 \text{ (stat)} \pm 0.0010 \text{ (syst)}$$

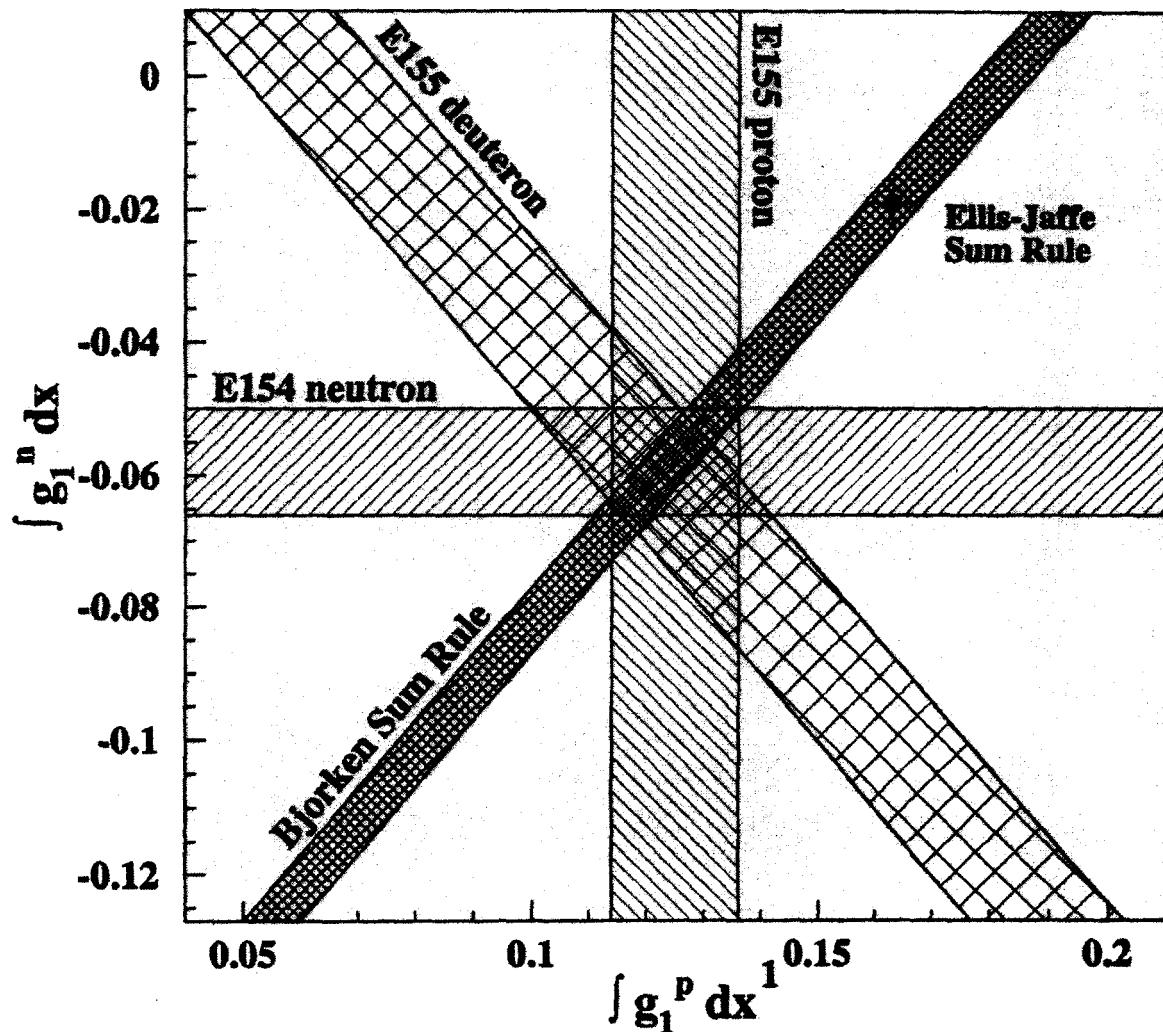
$$\sin^2 \theta_w^{\text{eff}} = 0.23097 \pm 0.00024 \quad \pm 0.00013$$

- The  $A_{\text{lepton}}$  can also be measured from their left-right-forward-backward asymmetries

# SLAC Fixed Target Program 1990 - 1999

Internal Spin Structure of the Nucleon

Test of QCD and QPM Sum Rules



$$\Delta q \sim 0.2 \pm 0.1$$

$$\Delta G \sim 1.7 \pm 1.0$$

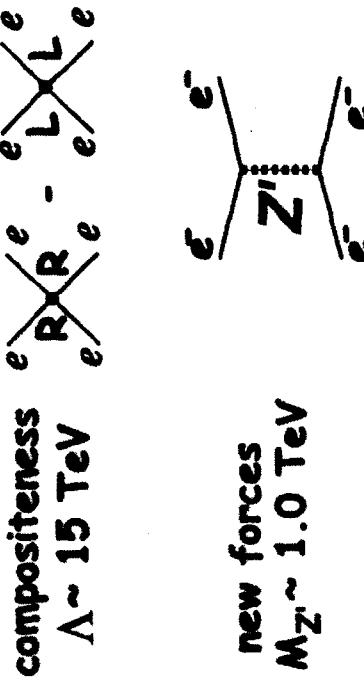
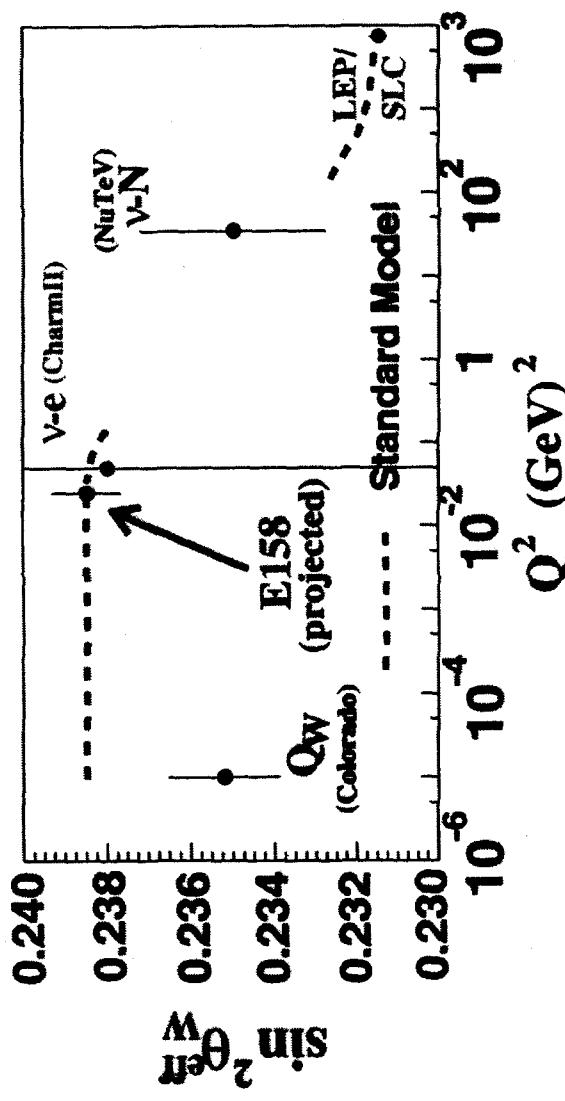
# SLAC E158 in End Station A

*Precision Measurement of the Weak Mixing Angle in Moller Scattering*

**Goal: World's best  $\sin^2 \theta_W$  away from the Z pole**

$$A_{LR} = \frac{\sigma_{+-} - \sigma_{++}}{\sigma_{+-} + \sigma_{++}} = -\frac{A_Z}{A_\gamma} = 0.32 \text{ ppm}$$

$$\delta(A_{LR}) = +/- 7\% +/- 3\%$$

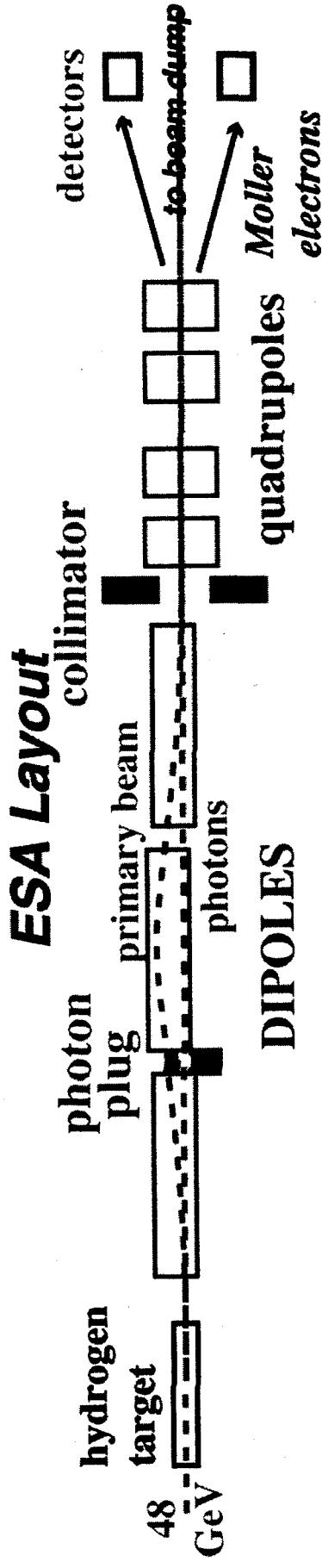
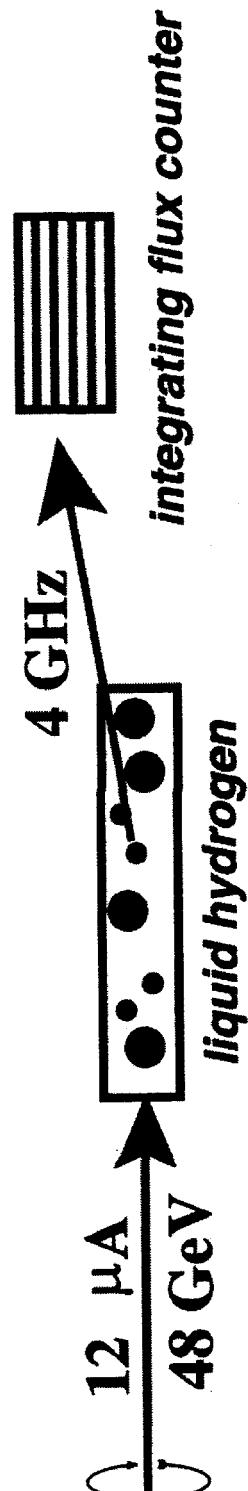


# E158 Status

## E158 Collaboration

American University	Syracuse University
Caltech	Smith College
Kent State University	Jefferson Lab
Princeton University	UMass Amherst
SLAC	Saclay

- \* **ESA cleanup done:** February 00
- \* **Construction:** ~ 8 months
- \* **checkout:** ~ 3 months



*Goal: ready for physics in early 2001*

# Data from SLAC

## (Continued)

### • CP Violation and Heavy Flavor Physics

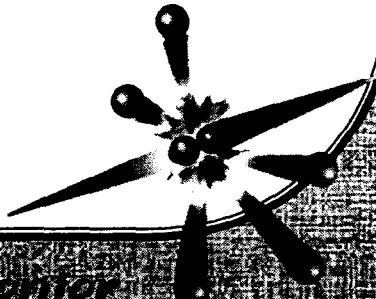
- PEP-II has delivered  $12 \text{ fb}^{-1}$  of which BABAR has recorded  $11 \text{ fb}^{-1}$

Peak luminosities of  $2 \times 10^{33} \text{ cm}^{-2} \text{ sec}^{-1}$  are routine. The current record is  $2.2 \times 10^{33} \text{ cm}^{-2} \text{ sec}^{-1}$

Integrated luminosity of  $> 100 \text{ pb}^{-1} / \text{ day}$  are routine. The current record is  $150 \text{ pb}^{-1} / \text{ day}$ . The design performance specification was  $135 \text{ pb}^{-1} / \text{ day}$

Current run will go through October 2000.  
Anticipate at least  $25 \text{ pb}^{-1} \Rightarrow \delta \sin 2\beta \cong 0.1$

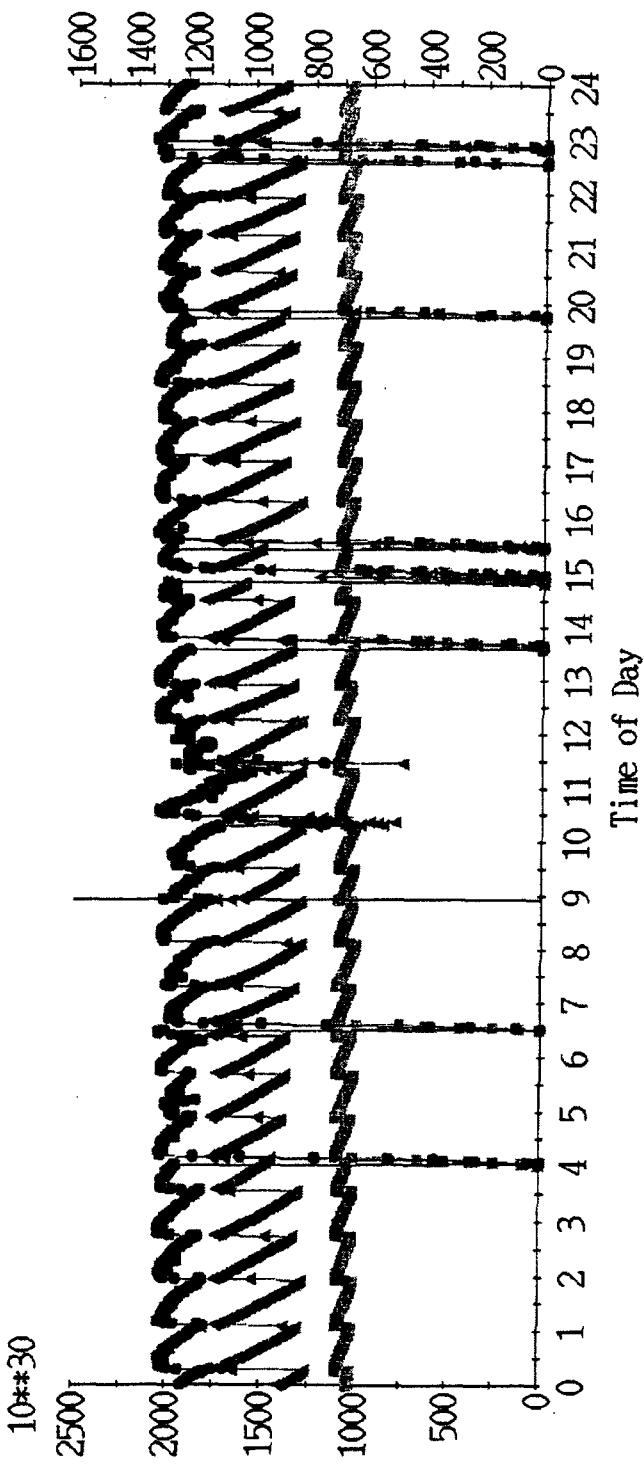
- SLD will soon complete its measurement of  $B_s$  mixing -  $\Delta m_s > 16 \text{ ps}^{-1}$  is anticipated



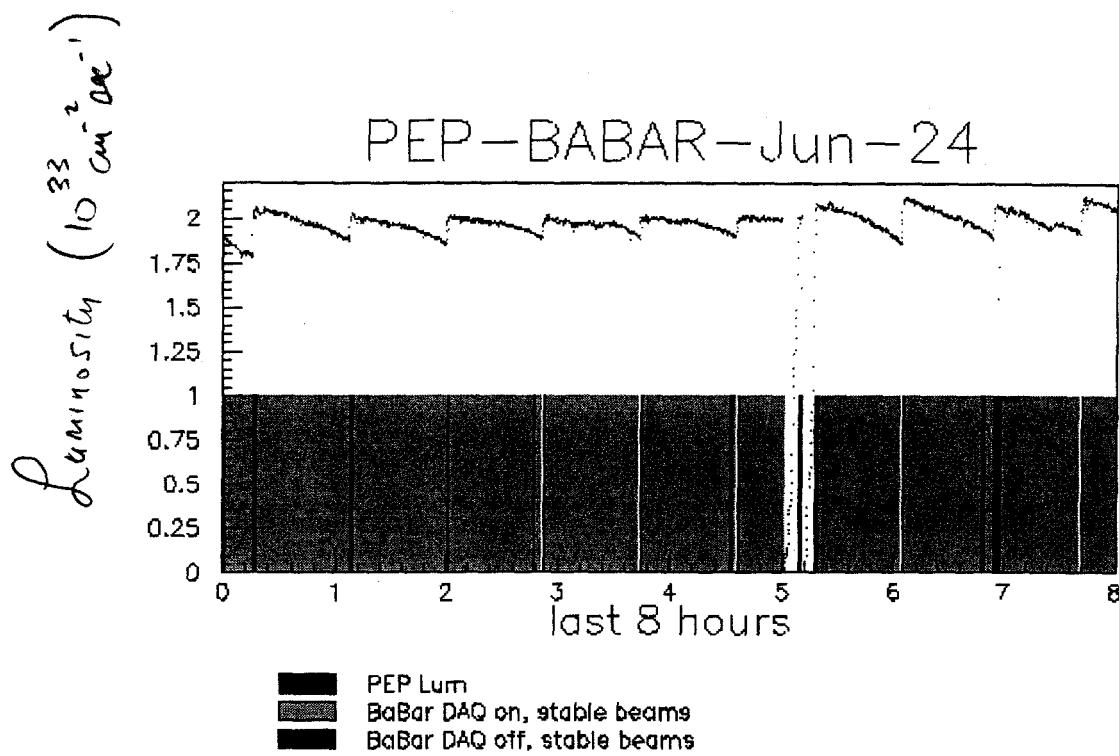
# PEP-II Luminosity

I HER	I LER	Luminosity	Spec Lum	E HER	E LER	E CM
699.99	1114.34	2011	1.74	8976	3125	10593
mA	mA	$10^{**30}$	$N * 10^{**30} /$	Mev	Mev	Mev
			$mA^{**2}$			
N Buckets/HER Pattern				N Buckets/LER Pattern		
665	0:3320:5	665	0:3320:5			
Last Owl/Day/Swing/24 Hr:	51.6	46.0	52.7	150.3	Shift: 5.94	/pb

PEP-II Luminosity and Currents



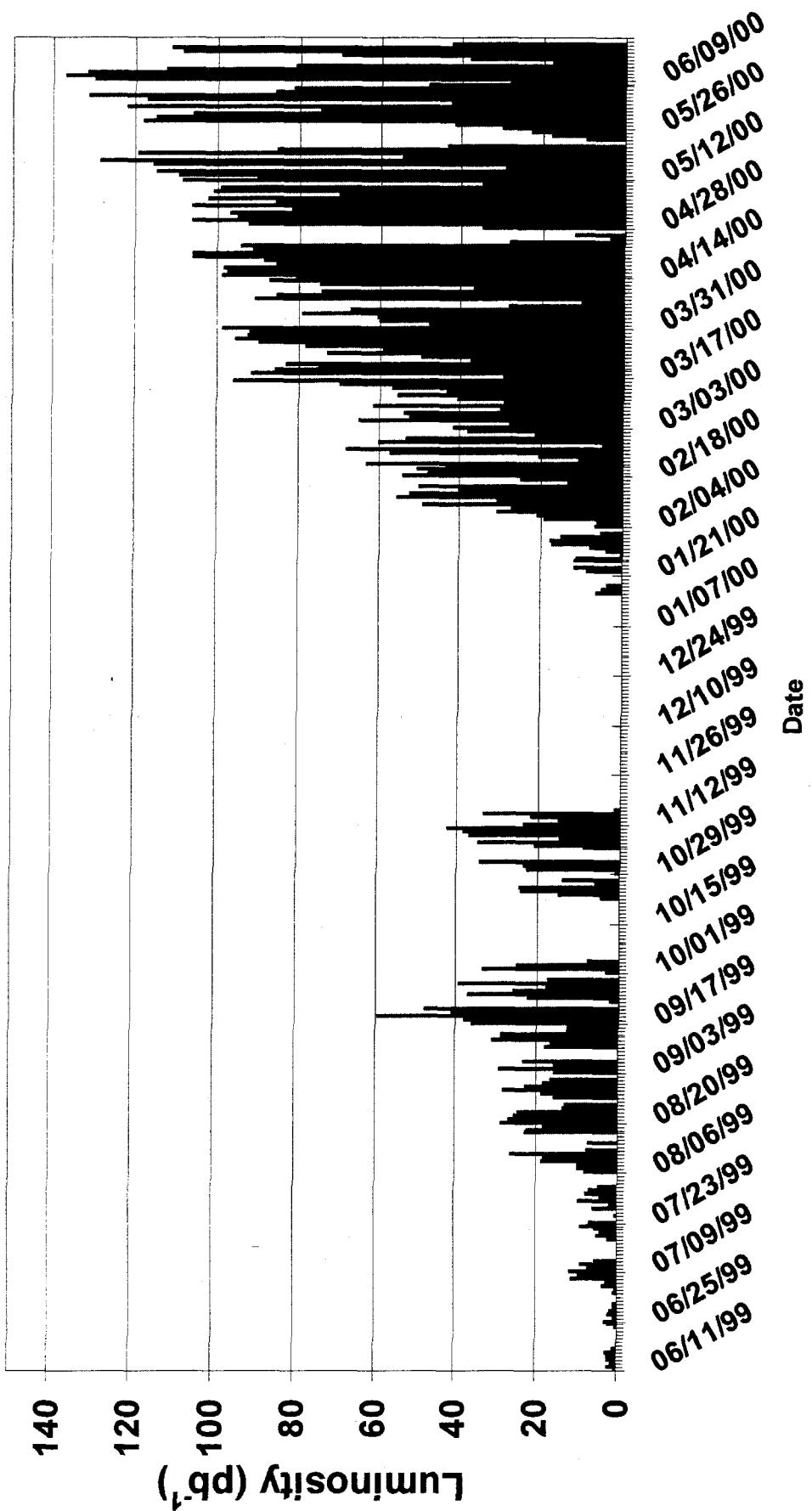
06/11/2000 08:56:17



8 hour snapshot - available on web

{ PEP-II delivered  $155 \text{ pb}^{-1}$  on June 24, 2000  
BABAR logged  $148 \text{ pb}^{-1}$

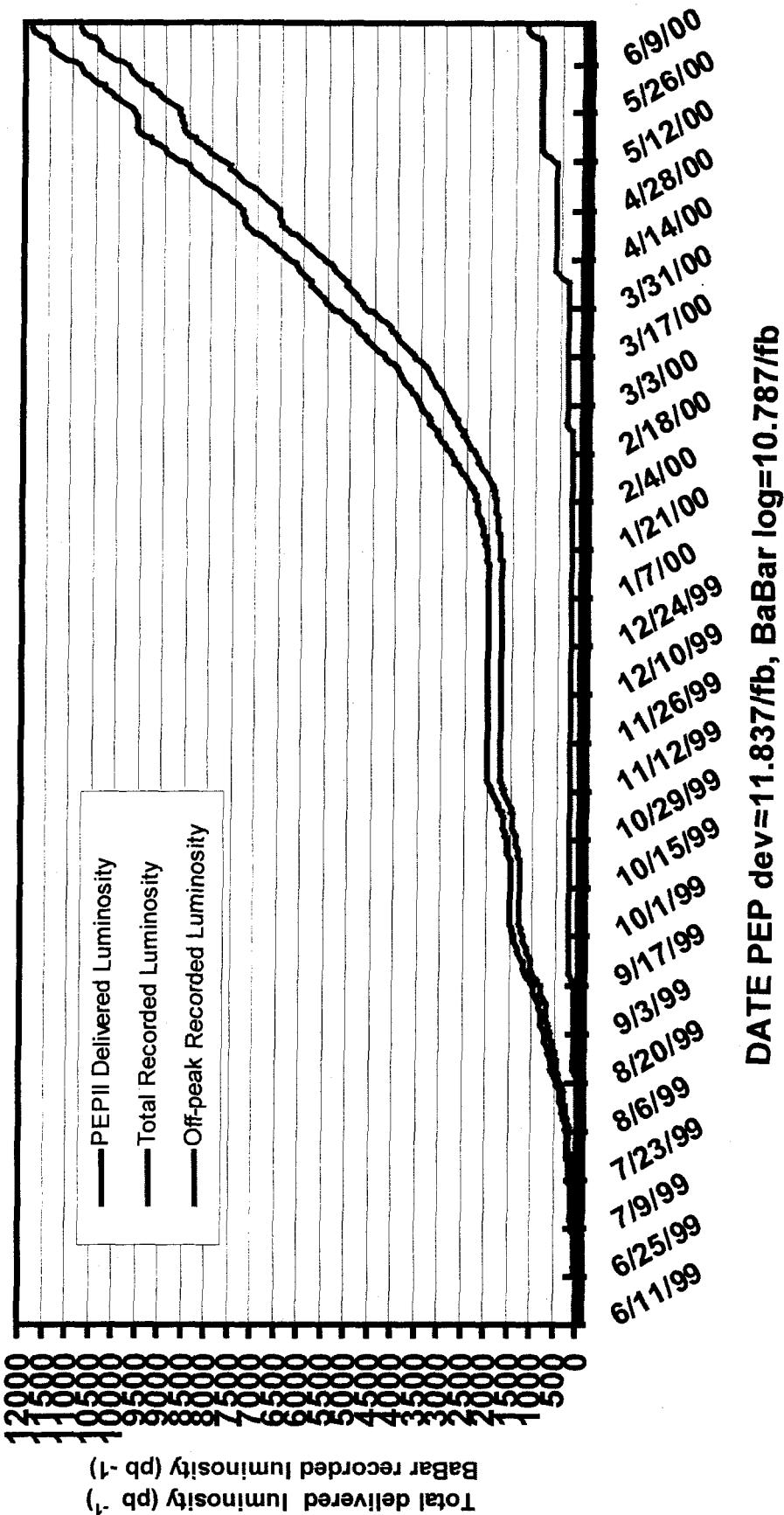
## BaBar Daily Recorded Luminosity



Friday, June 23, 2000

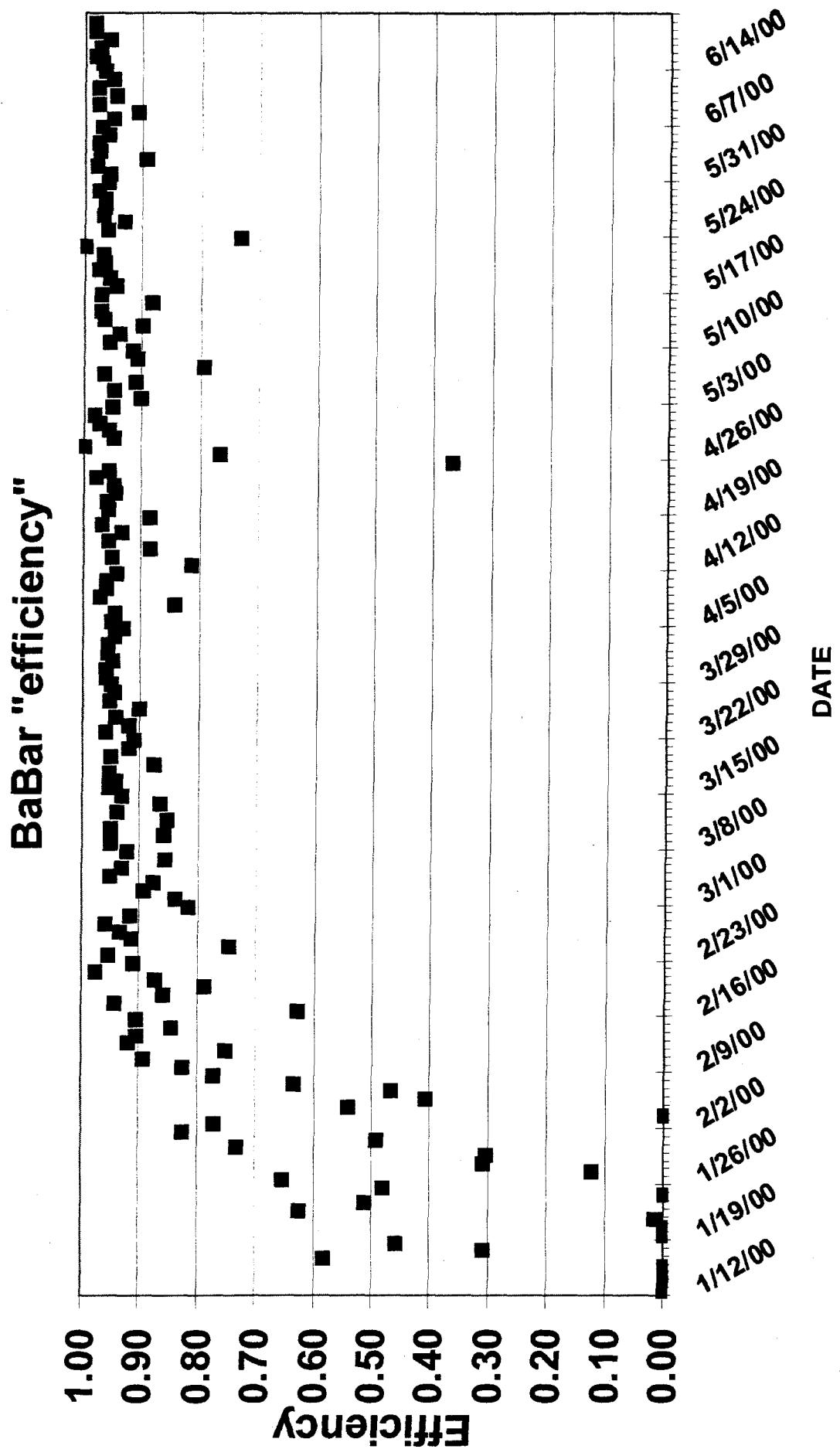
R. W. Kadel, W.Toki & A. Khan

## BaBar Recorded Luminosity - 1999 + 2000



Friday, June 23, 2000

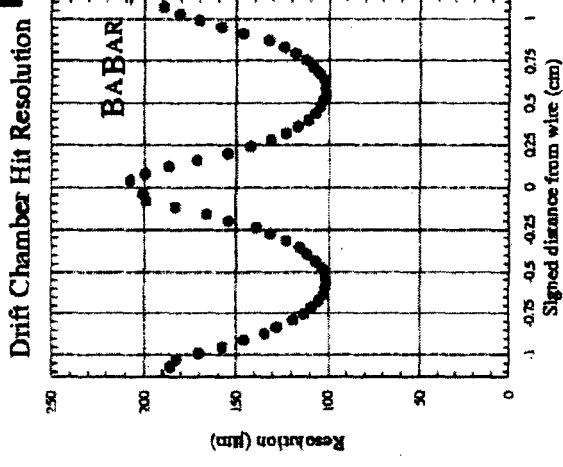
R. W. Kadel, W.Toki & A. Khan



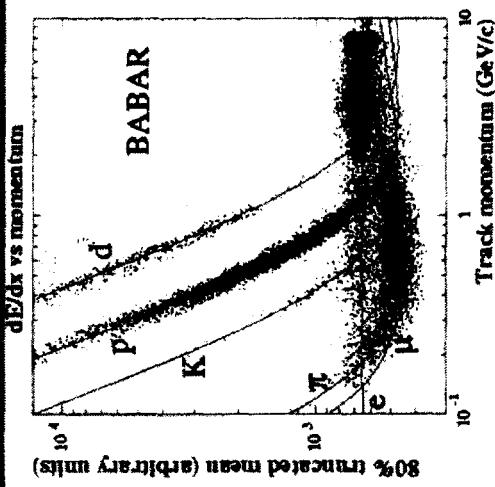
Friday, June 23, 2000

R. W. Kadel, W. Toki & A. Khan

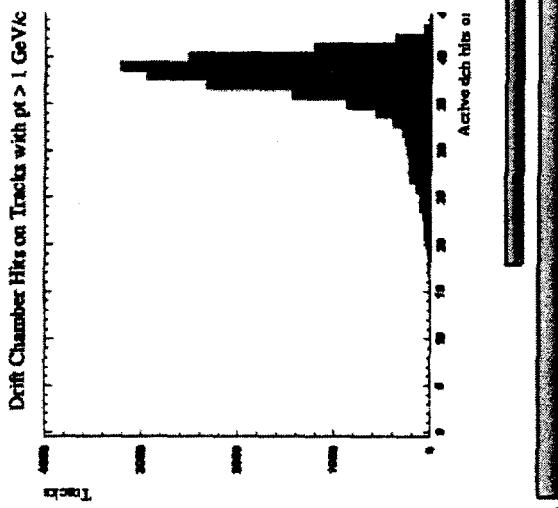
# System Performance DCH



Average resolution  
in the cell is **125  $\mu$ m**  
compared to the  
design goal of  
**140 $\mu$ m**



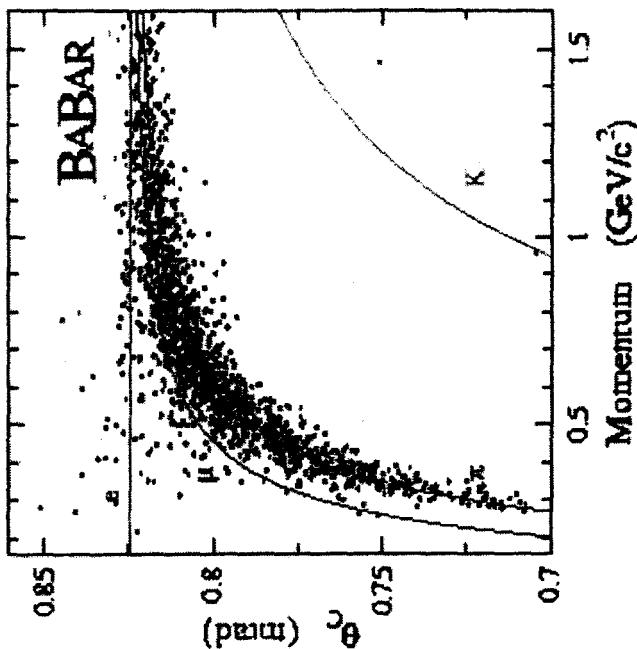
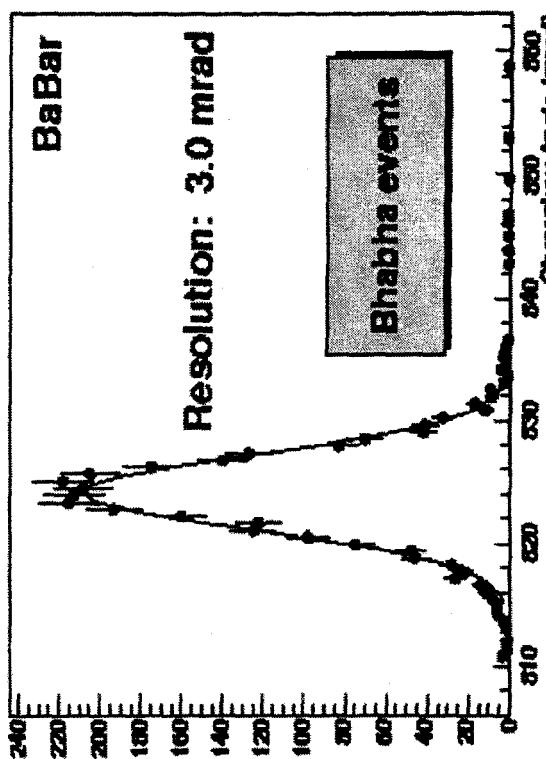
Distribution of  
hits on track for  
multihadron



40 layers

# System Performance - DIRC

**Reconstructed Cherenkov Angle per track for Bhabha's**

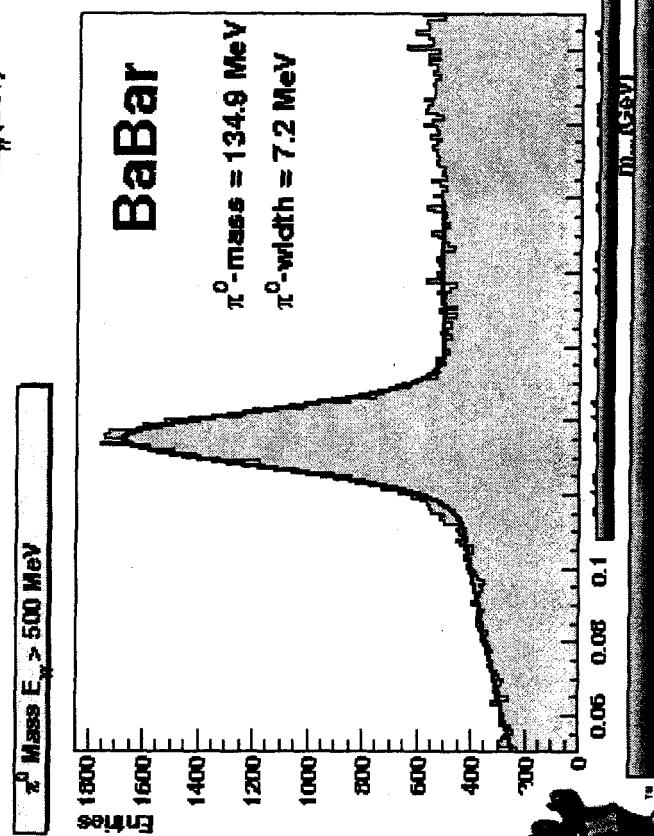
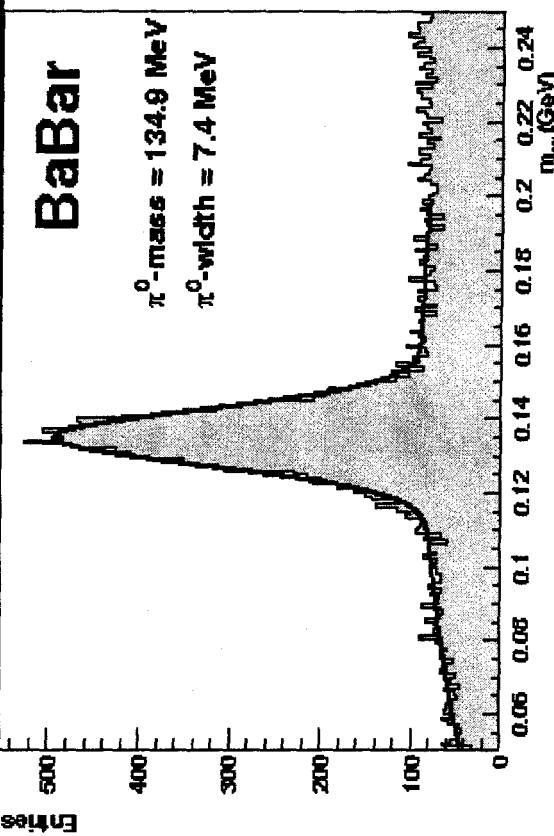


*Cherenkov Angle  
for charged  $\pi$ 's from*



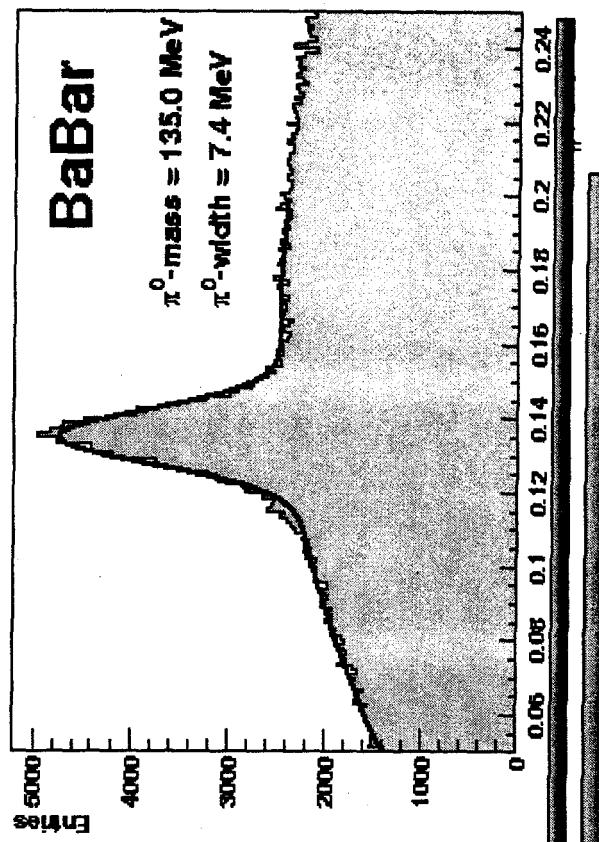
(Capability for low momentum  $\pi$  /  $\mu$  separation)

# Systematic Performance E/F/C



$\pi^0$  Mass

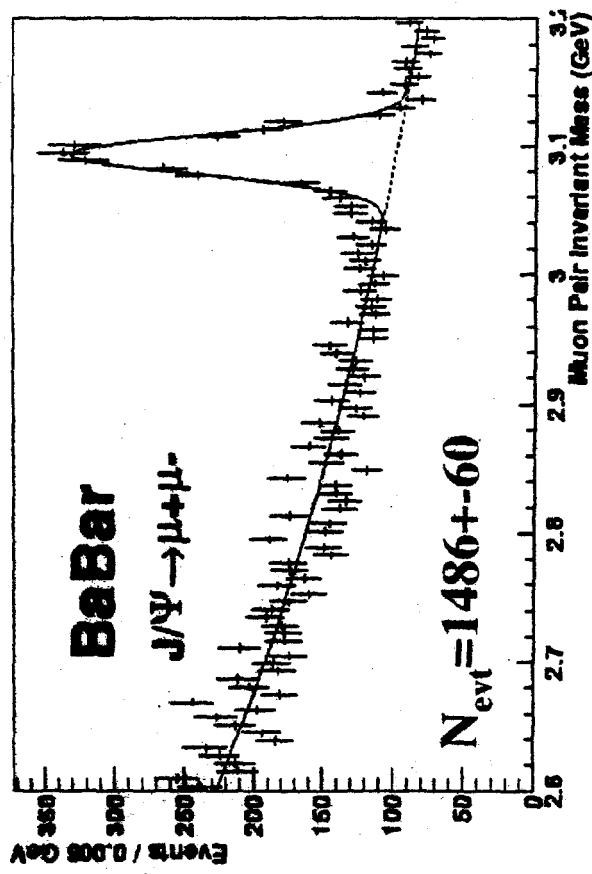
From B-hadronic events



# Inclusive J/ $\Psi$

$L_{int} \sim 1.9 fb^{-1}$

Physics of Charmonium

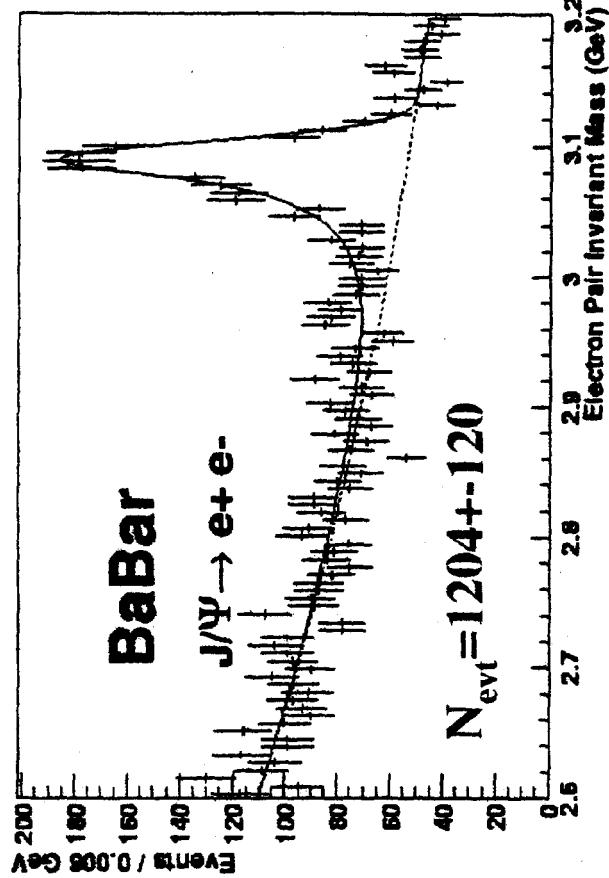


$$M_{\mu\mu} = 3093.4 \pm 0.7 \text{ MeV}$$

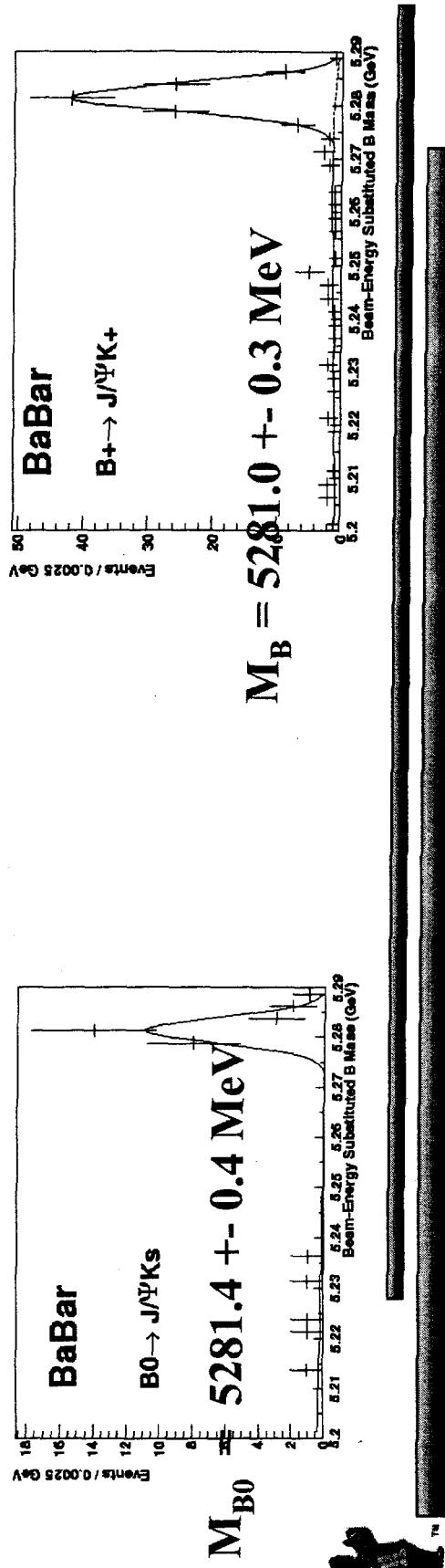
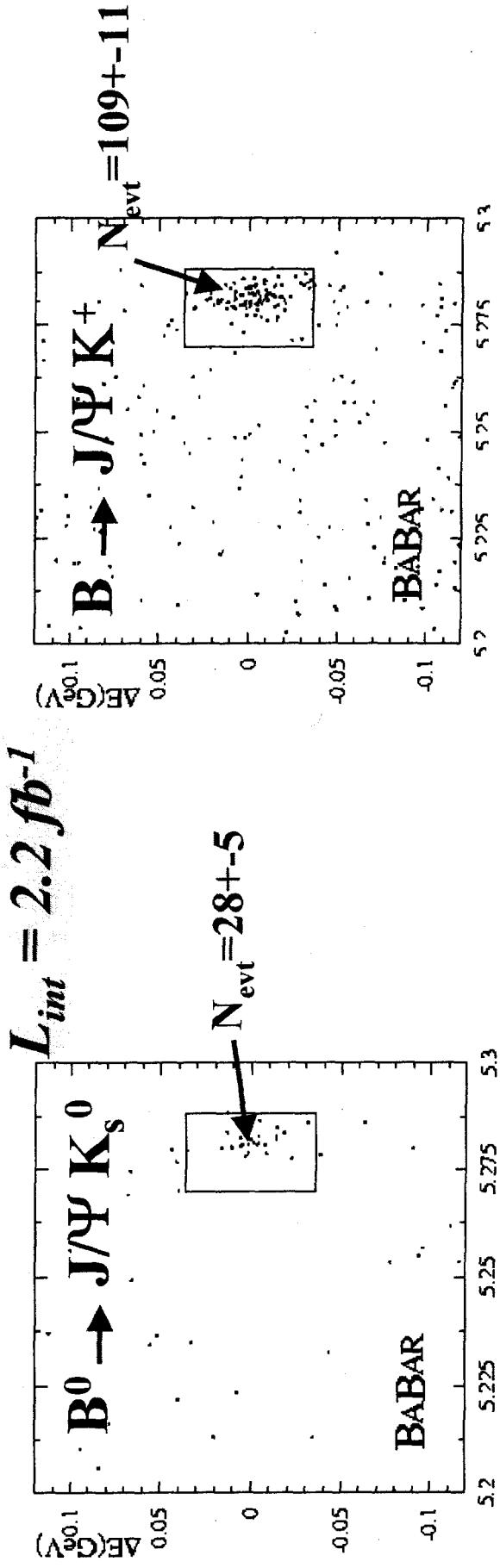
$$\sigma_M = 15.3 \pm 0.7 \text{ MeV}$$

$$M_{ee} = 3090.0 \pm 1.0 \text{ MeV}$$

$$\sigma_{ee} = 14.0 \pm 1.0 \text{ MeV}$$



# Exclusive J/Ψ K's



# B Factory - Future Plans

- Get machine to design  $\mathcal{L}$  of  $3 \times 10^{33} \text{ cm}^{-2} \text{ sec}^{-1}$  by Summer 2000
- Work aggressively to upgrade  $\mathcal{L}$

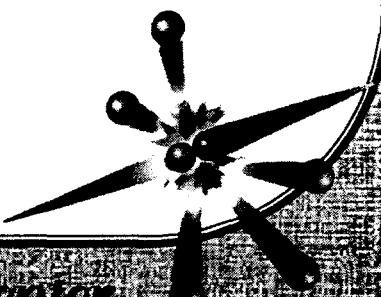
## Goals:

### A) $1.0 \times 10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$ by Xmas 2002

- We know how to achieve this
  - Increase stored current by adding more RF
- Requires modest changes to BABAR, major investment in BABAR computing

### B) $3.0 \times 10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$ by Xmas 2005

- Have ideas on how to do this - requires detailed study. Plans will solidify by end of calendar 2000
- Could have significant impact on BABAR if we reconfigure the geometry of the IR



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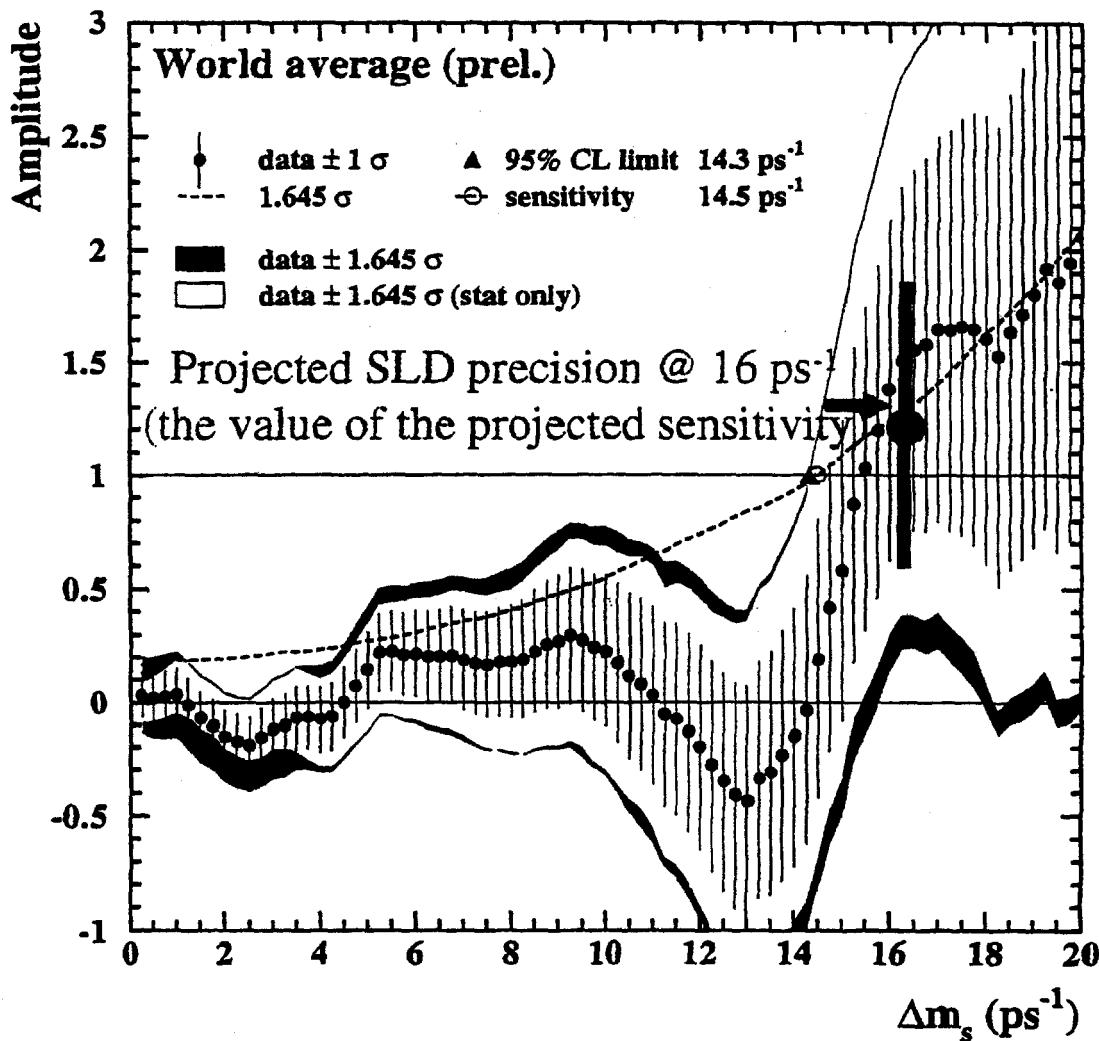
# The CKM Unitarity triangle at SLD : $B_s$ mixing

Measurement of  $B_s$  mixing constrains  $V_{td}$  and the position of the apex of the Unitarity triangle.

Answer question : Does CKM matrix explain CP ?

**The SLD has unique capabilities :**

- 100% eff. initial state tag (polar asymmetry)
- VXD3's superb vertex resolution (>3X LEP)



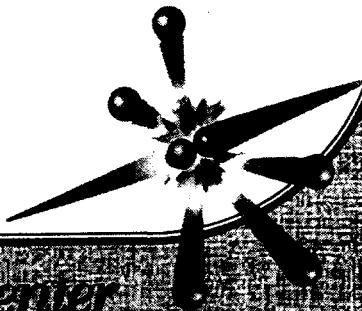
SM fits favor the region around  $16 \text{ ps}^{-1}$  for the  $B_s$  mixing frequency - Presently there is a hint of a signal in this region. If LEP achieves comparable precision, discovery is possible

# Data from SLAC

## (Continued)

- **Neutrino mass measurement**

- Marty Breidenbach, Charles Prescott, Peter Rowsen have joined Georgio Gratta from Stanford campus in exploring the feasibility of measuring the  $\nu$  mass using a Xenon TPC, using the neutrinoless double beta decay process.
- Has the potential to get down to the interesting mass level of  $\approx 0.01$  eV



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# EXO

## A very large Xenon double-beta decay experiment

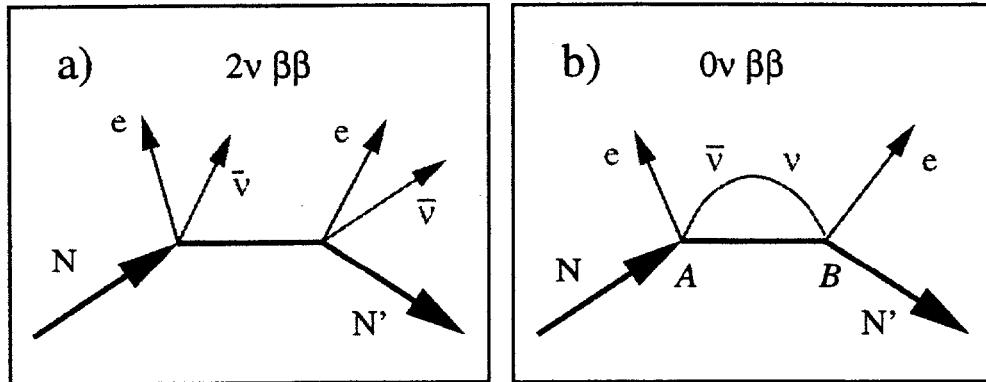


Figure 4: Feynman graphs relative to: a) 2-neutrino and (b) 0-neutrino double-beta decay processes.

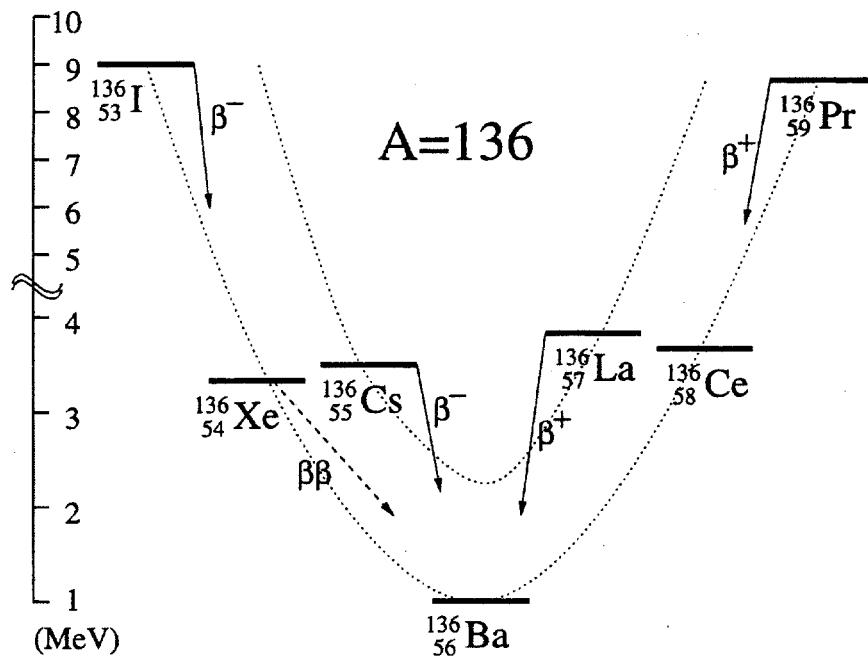


Figure 3: Simplified atomic mass scheme for nuclei with  $A=136$ . The parabolae connecting the odd-odd and even-even nuclei are shown. While  $^{136}\text{Xe}$  is stable for ordinary  $\beta^-$  decay, it can decay into  $^{136}\text{Ba}$  by a double-beta process.

## Xe TPC with Ba<sup>+</sup> Tagging

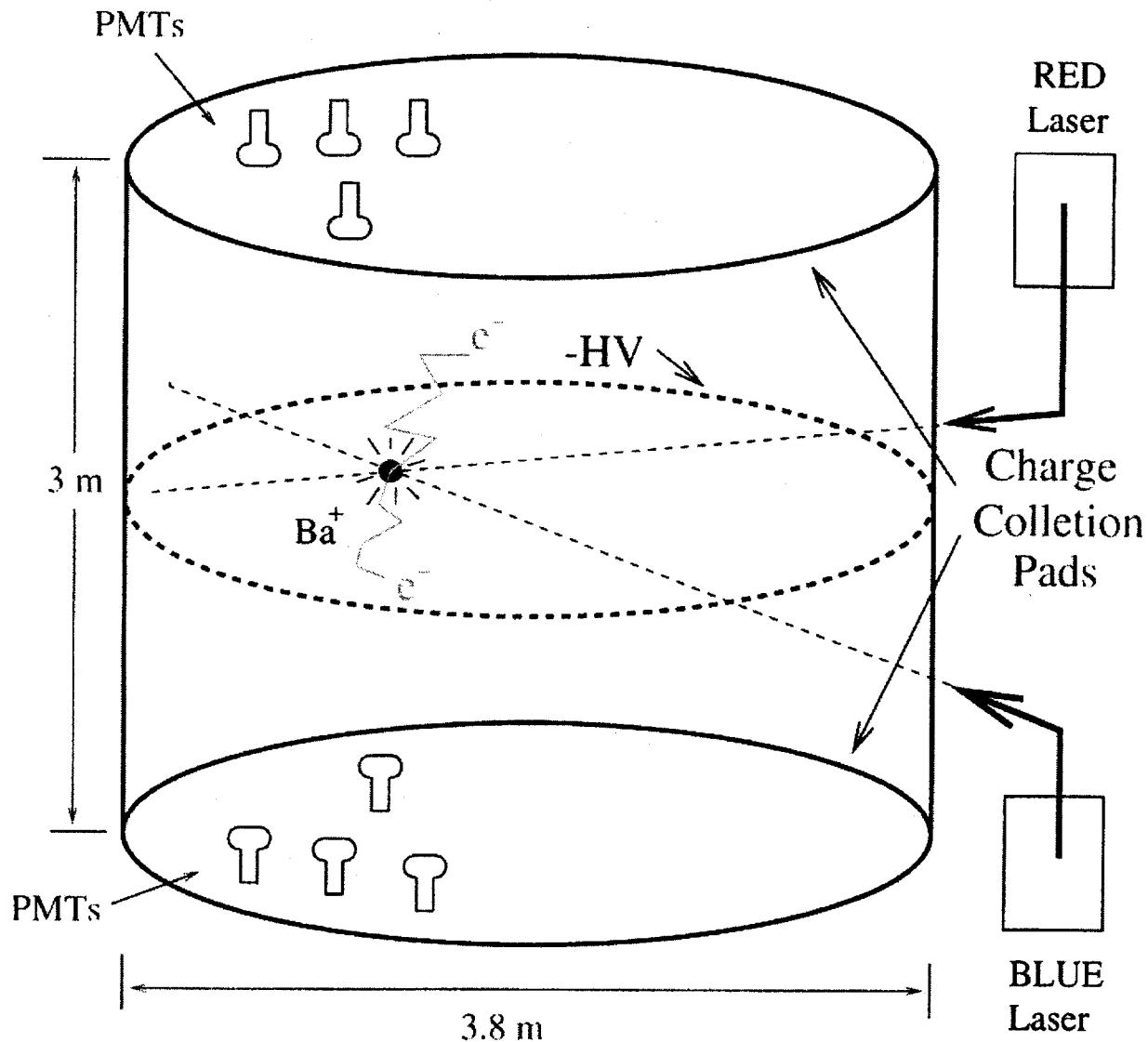


Figure 2: Conceptual drawing of the 1 ton double-beta decay detector. In order to suppress backgrounds from traces of natural radioactivity the two electrons emitted in  $0\nu\beta\beta$  decay are identified and localized by the TPC. The barium atom is then identified by directing laser beams of appropriate frequencies and power onto the reconstructed location. Only if a barium atom is present light will be absorbed and re-emitted confirming the event.  $0\nu\beta\beta$  event will be separated from  $2\nu\beta\beta$  events using the electron energy reconstructed in the TPC. The cosmic-ray background is suppressed by locating the detector deep underground. The 1 ton detector is well within the present technology. Up to 10 ton detectors can be built in the future either as single chambers or as clusters of smaller detectors.

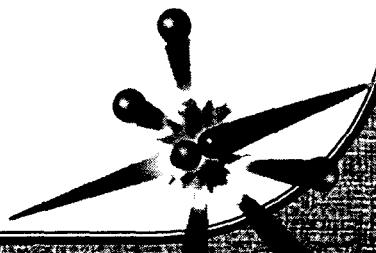
# A very large Xenon double-beta decay experiment

Isotope and Reference	Total Mass (kg)	Enrich. grade (%)	Det. eff. (%)	Meas. time (yr)	Bkgd. ( $\text{kg}^{-1}\text{yr}^{-1}$ keV $^{-1}$ )	$T_{1/2}^{0\nu\beta\beta}$ (yr)	$\langle m_\nu \rangle$ (eV)	NSM
$^{76}\text{Ge}$ [14]	11	86	100	2.6	0.2	$1.1 \times 10^{25}$	0.46	1.3
$^{136}\text{Xe}$ [19]	5.3	63	30	1.47	0.02	$4.4 \times 10^{23}$	2.2	5.2
$^{130}\text{Te}$ [18]	0.33	34.5	100	0.45		$5.6 \times 10^{22}$	2.9	6.1
$^{136}\text{Xe}$ this proj.	1000	65	70	5	0*+	$8.3 \times 10^{26}$	$5.1 \times 10^{-2}$	0.14
$^{136}\text{Xe}$ this proj.	10000	65	70	10	1.8 events	$1.3 \times 10^{28}$	$1.3 \times 10^{-2}$	$3.7 \times 10^{-2}$
					0*+ 5.5 events			

Table 4: Comparison between the parameters and results achieved by the best present double-beta decay experiments and the project described here. As explained in the text the new techniques that we plan to use to reduce the background are essential to fully utilize the large mass of isotopic species. All other experimental parameters are assumed to be the same as in the Gotthard experiment. We list here, together, the case of an initial detector with 1 ton of xenon and the final results possible with 10 tons of xenon and a very long (10 years) data-taking period. The  $^{136}\text{Xe}$  enrichment grade used here is intermediate among the options (and price ranges) shown in Table 5. The quantities marked with \* are radioactivity backgrounds that are assumed to be negligible as discussed in the text. In addition the background from mis-identified  $2\nu\beta\beta$  decays is also shown in total events in each exposure.

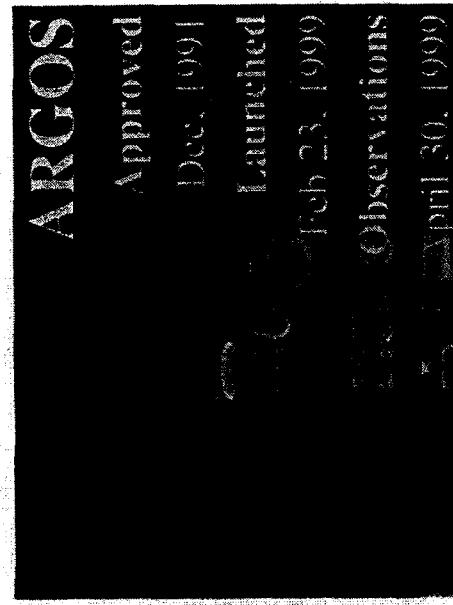
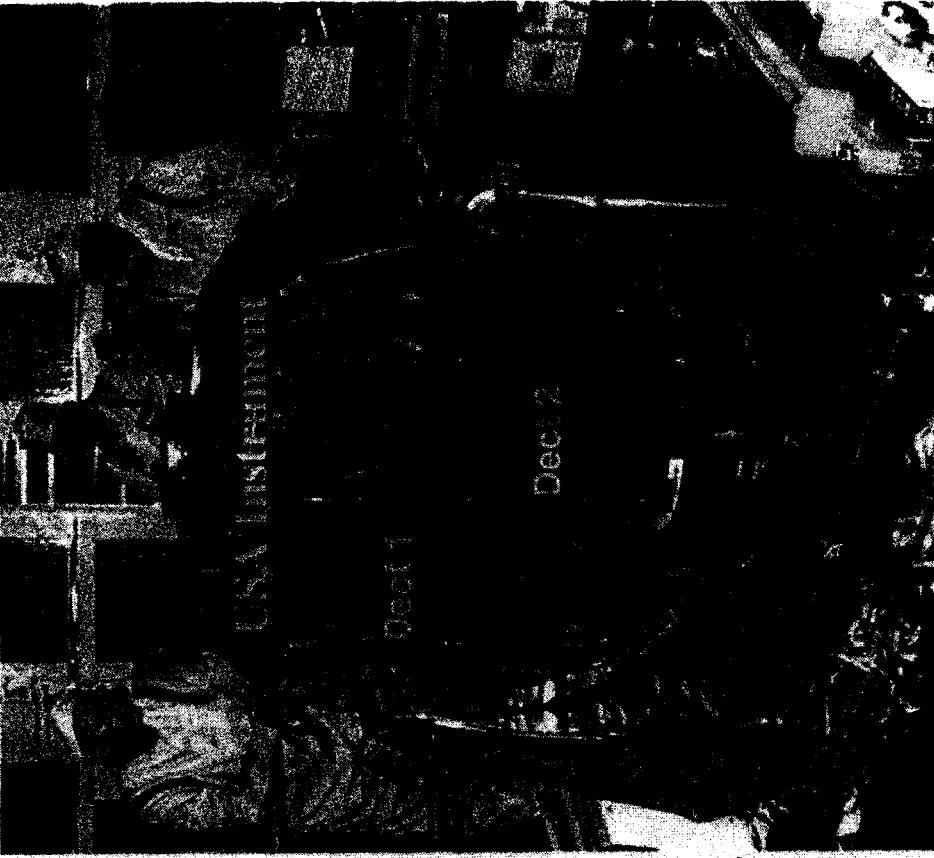
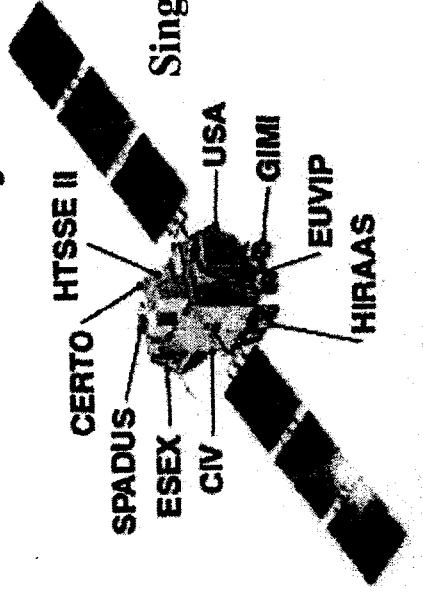
# Non-Accelerator Physics

- The disciplines of particle physics and astro-physics increasingly confront an overlapping physics agenda
- A program of non-accelerator physics is crucial to the understanding of fundamental issues like
  - \* What is the Dark Matter?
  - \* Cosmological constant. What is the force behind the Dark Energy?
  - \* Strong gravity
  - \* What provides the acceleration for  $> 10^{20}$  eV cosmic rays?
  - \* Gamma Ray Bursts
  - 
  - 
  - 
  -
- Particle Astrophysics and Cosmology is a rapidly evolving and exciting field. The detector tools for many of the leading experiments are those of HEP
- At SLAC, we have joined this non-accelerator based adventure by our participation in the USA experiment and in the GLAST experiment

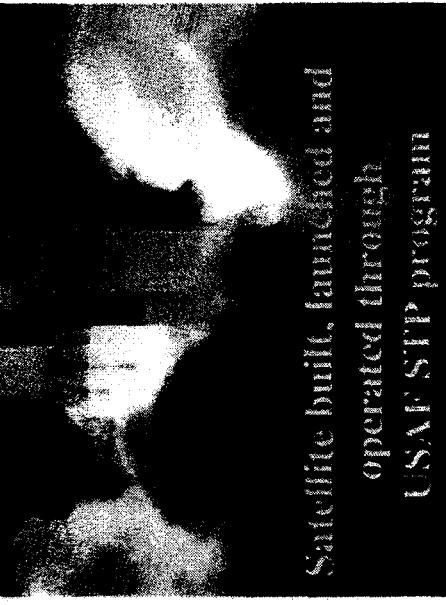


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# The USA X-Ray Timing Experiment on ARGOS



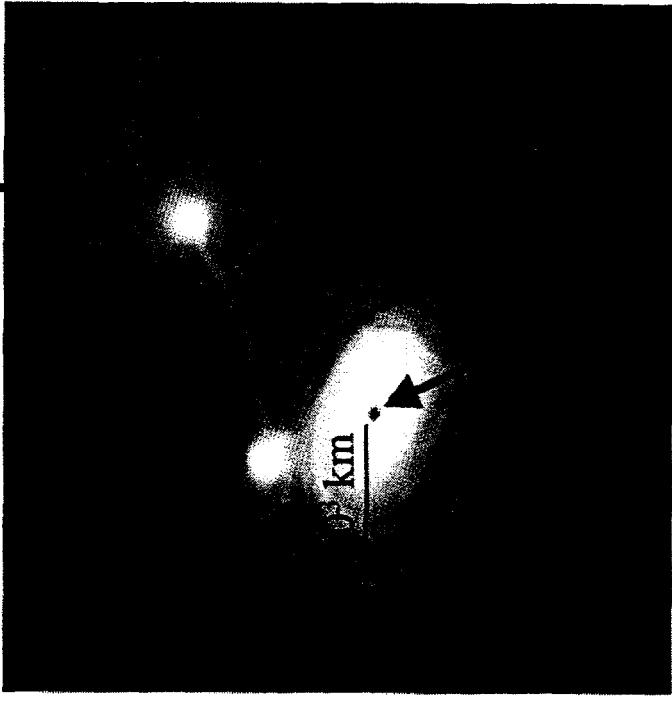
- 1-20 KeV usable energy range ~15% spectral resolution.
- Observe ~30 brightest X-ray sources with ~1 month observing time for each source, e.g., currently have ~700 ksec of data on Cyg X-1.



Built and Operated by a DOD-DOE Collaboration  
NRL: Lead on instrument development (K. Wood, P.I.).  
SLAC: Partner in instrument, mission, data analysis.  
SSU: Data analysis, education and public outreach.  
MIT, NASA Ames, UofCalgary: Data analysis.

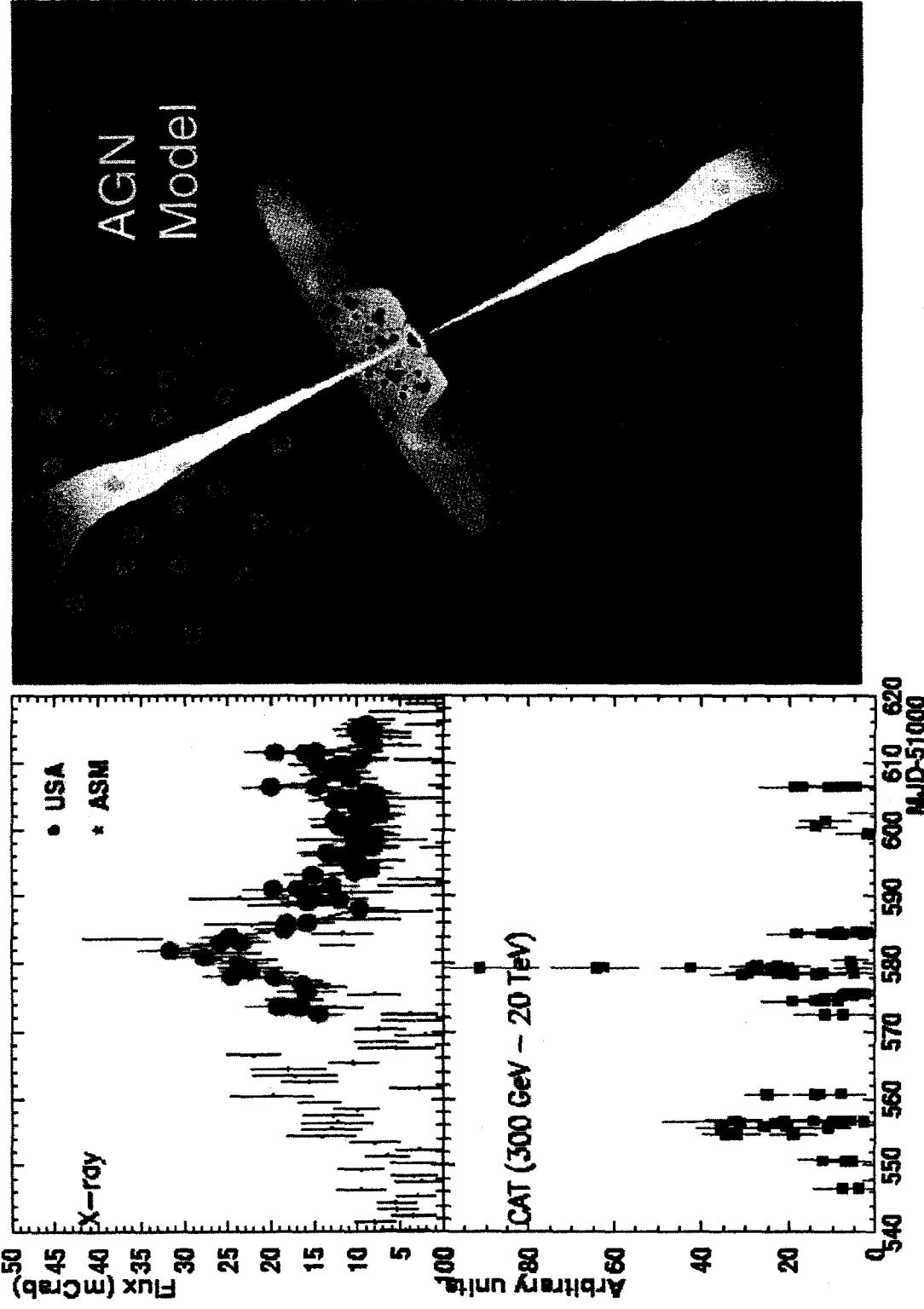
Satellite built, launched and  
operated through  
USA's STP program

## *USA (Unconventional Stellar Aspect) Particle Astrophysics Goals*

- Accreting binaries release  $\sim 1 - 1$  GeV of gravitational energy per proton accreted, mostly in 1-10 KeV X-rays.
  - Luminosity is frequently  $> 10^{38}$  ergs/s in this band.
- Mass-Donor Companion Star
- 
- Accretion Disk      Neutron Star, BH or ? ( $\sim 10\text{-}100$  km)
- X-ray timing: observe arrival time series of X-ray photons. Probes compact mass region of accreting binary where relativistic gravitational effects occur, with high signal-to-noise.
  - Exploration of Strong Field Gravity Effects  
Include:
    - Search for Inner edge of accretion disk around BH, determination of BH spin.
    - “Disko-seismology” for BH; GR driven modes in inner edge of disk for BH.
    - Gravitomagnetic Precession in the Inner Disk of BH and NS binary systems-- Lens-Thirring effect that causes the plane of the accretion disk, near its inner edge, to precess in bursts. This produces QPOs in X-ray (has been observed?).
    - Search for New types of collapsed Stars, e.g., Q-stars, i.e., QCD in different phase--equation of state of compact stellar objects.
    - Jet acceleration by rotating black holes

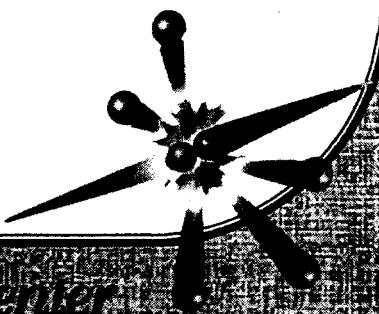
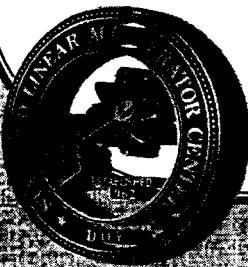
# Mkn 421 in Flare: Multi-Wavelength Campaign 2/2000

USA X-ray, CAT (Themis Cherenkov array in France) TeV gammas  
Also Optical and Radio not shown below. Data is Preliminary



# GLAST

- **Multi-national collaboration funded by the HEP and SPACE agencies of US, Italy, France, Japan ...**
  - We need to ensure a successful and effective partnership between NASA and DOE. Science will be well served by the successful marriage of the DOE's experience with Detectors and NASA's experience with Space ventures
- **The construction of the instrument is centered at SLAC:**
  - SLAC is providing the central management team, the core engineering team, project management financial tools and staff, module assembly and testing infrastructure and staff
  - SLAC is providing the electronics and software leadership and supporting staff and will provide the computing for data reduction, storage, ....
  - SLAC's major contribution to device specific hardware is in the silicon tracker, in collaboration with UCSC, Japan and Italy
  - GLAST will be launched into space in 2005



Space Radiation Analysis Group (STAR)

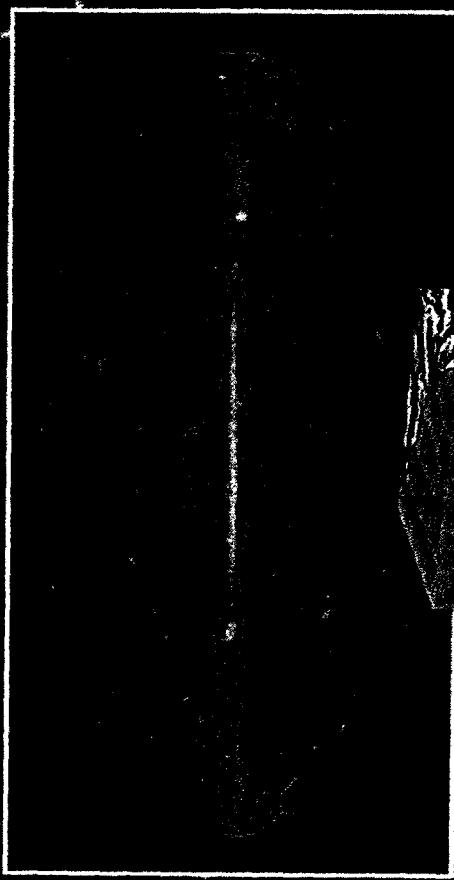
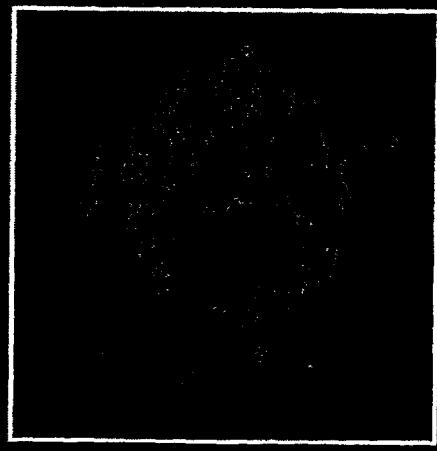
# GLAST SCIENCE

0.01 GeV

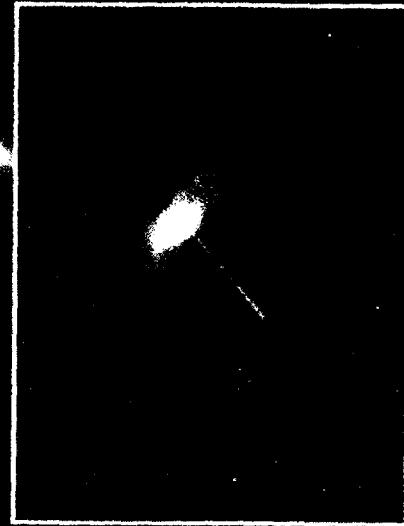
1 GeV

10 GeV

Supernova Remnant  
Map the High-Energy Universe



AGN



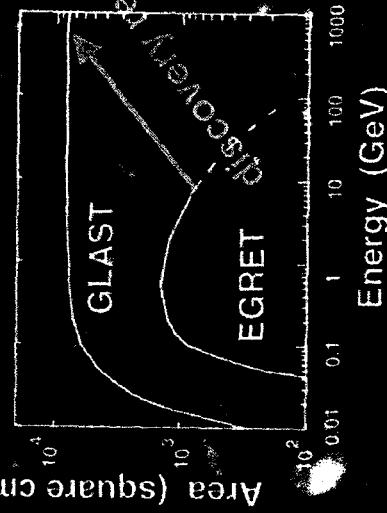
- GLAST pulsar survey: provide a window on the galactic neutron star population

- "Map" pulsar magnetospheres and understand the physics of pulsar emission

- Origin of cosmic-rays: characterize extended supernovae sources

- Determine the origin of the isotropic diffuse gamma-ray background

- $\gamma$  decay of relics from the Big Bang



- Physics in regions of strong gravity, huge electric & magnetic fields: e.g. particle production & acceleration near the event horizon of a black hole

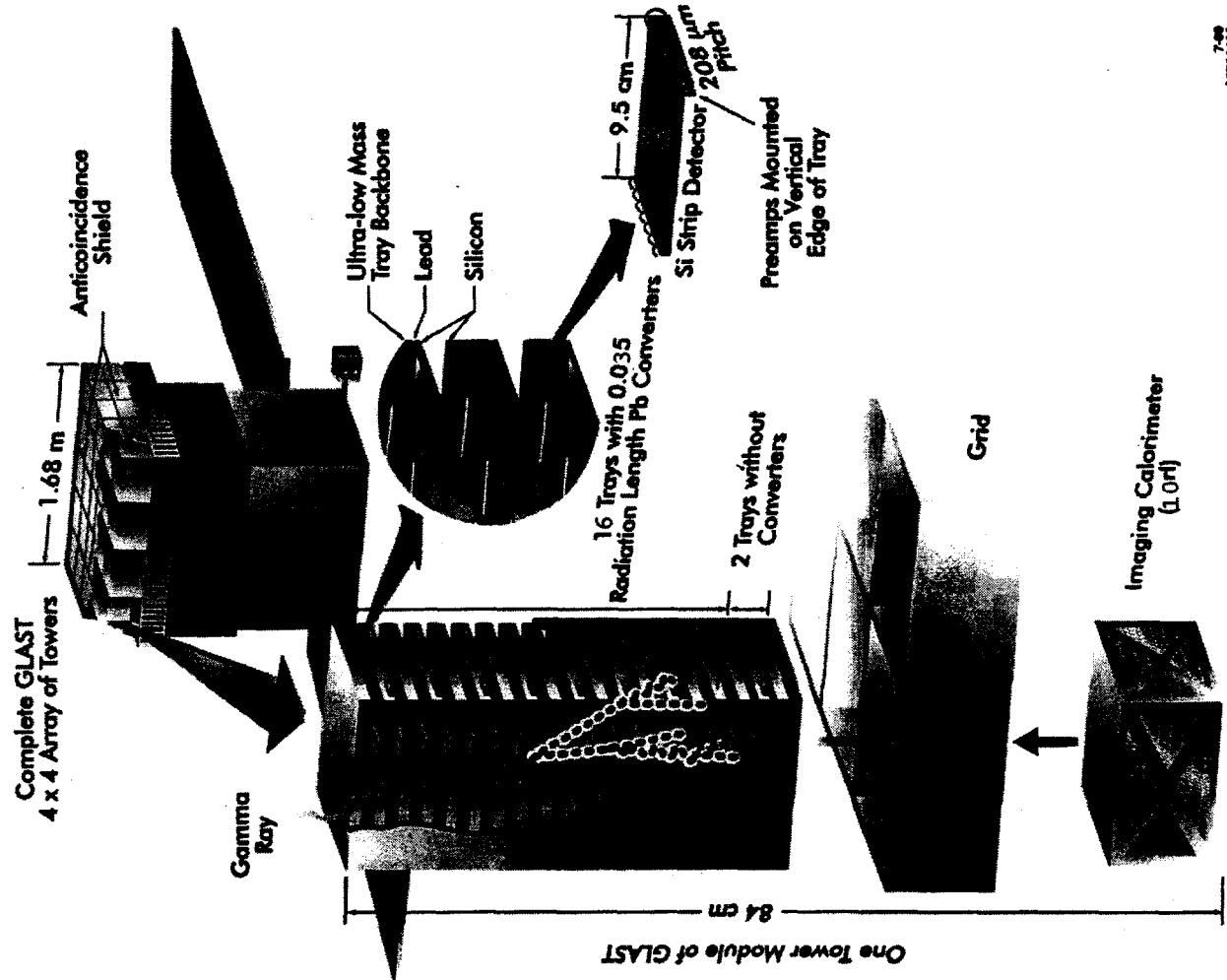
- Use gamma-rays from AGNs to study evolution of the early universe

- Physics of gamma-ray bursts at cosmological distances

- Probe the nature of particle dark matter: e.g., WIMPs, 5-10 eV nucleon

# Current GLAST Baseline Instrument Concept

Some Dimensions are Distorted  
for Clarity of Presentation



## *GLAST Spacecraft and Instrument*

Instrument is modular. Each module contains elements of the complete telescope:

- tracker (TKR): single-sided silicon-strip detectors & converters, arranged in 18 x,y tracking planes totaling 0.6 radiations lengths;
- calorimeter (CAL): segmented, 8 layer hodoscopic array of CsI(Tl) crystals, 10 r.l. thick; readout with PIN photodiodes;
- data acquisition system (DAQ): 16 identical boards in 4-way redundant network. Parallel serial readouts with FIFO buffers;
- anticoincidence shield (ACD): mosaic of plastic scintillator tiles covering top and sides of array.

**GLAST**

# **What Lies Beyond 2005?**

## **Global Planning**

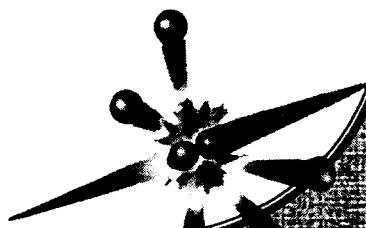
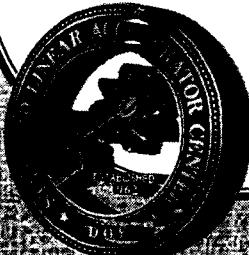
- **What role will the US program play in the post 2005 era?**
- **What are some of the key elements which will shape the major planning exercise that we are embarking on in the upcoming year?**
  - ↳ Resources - both human and fiscal - are restricted in every region of the HEP world

Without increased international cooperation we risk extinction. Excessive regionalism will greatly reduce the scope of our field

Ideally, we should be crafting a world plan - HEP should be doing its planning on a global basis

Within the US, we need to collaborate more. We would benefit from

  - ↳ more interagency collaboration
  - ↳ more interlaboratory collaboration
  - ↳ greater involvement of the University community in developing the tools of the future



*Stronger Together, Accelerating Growth*

# What Lies Beyond 2005?

## (Continued)

- Maybe its time for a different planning model?

Traditionally we focus narrowly on “selling” the next frontier machine. This is a short term and somewhat narrow approach

Perhaps we should develop a long range roadmap - a ≈ 30 year vision which incorporates several major themes

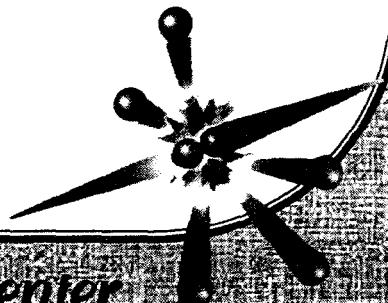
- ↳ Ideally such a roadmap would be imbedded in the world plan

- What might be the elements of such a plan?

Major lesson of the past 30 years — the necessity for complimentary accelerator probes. Without the combined strengths of proton and electron machines, we would not have the clear and detailed picture which is the Standard Model

The reach of the Main Injector and LHC is impressive — but these machines will not provide the full detail needed to unravel fully the electro-weak symmetry breaking

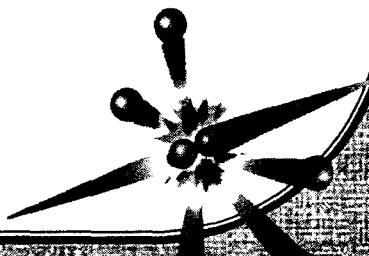
- ↳ We will need the complimentary input from an  $e^+e^-$  machine



# What Lies Beyond 2005?

## (Continued)

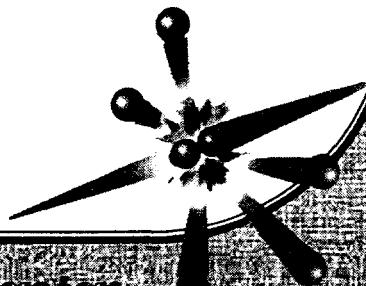
- Our 30 year roadmap needs to incorporate both of these accelerator probes. Our vision should not be captive to the 1 TeV energy scale; we need to be thinking how we evolve electron and proton collisions to the 5-10 TeV energy scale
- In addition, we need to develop more powerful ( $\approx$ 5MW) proton drivers as sources for intense, high energy  $\nu$  beams. Many branches of science need such drivers — opportunity for collaborative development



# How is SLAC Participating in Long Term Development?

## A) NLC

- SLAC continues to be a leader in the development of electron-positron linear colliders
  - SLC was the key element in spawning the worldwide effort
- It is crucial to continue the push towards a warm RF alternative for a linear collider
  - SLAC continues its strong R&D collaboration with KEK. This can serve as a model for International collaboration
  - FNAL has taken the important and crucial step to join SLAC, LBNL, LLNL as a full partner in the US-based R&D effort
- Accumulated impact of data from LEP, SLC and Tevatron argue strongly for an initial center of mass energy of 500 GeV (see Van Kooten's talk tomorrow)



*Stanford Linear Accelerator Center*



**International Committee for Future Accelerators  
Sponsored by the Particles and Fields Commission of IUPAP**

12 August 1999

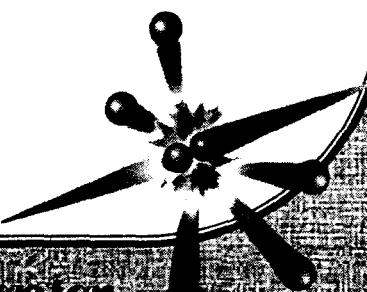
**ICFA Statement on Linear Colliders**

Scientific panels charged with studying future directions for particle physics in Europe, Japan, and the United States have concluded that there would be compelling and unique scientific opportunities at a linear electron-positron collider in the TeV energy range. Such a facility is a necessary complement to the LHC hadron collider now under construction at CERN. Experimental results over the last decade from the electron-positron colliders LEP and SLC combined with those from the Tevatron, a hadron collider, have led to this worldwide consensus.

Reviews of the latest experimental results at the Lepton-Photon 99 conference point ever more clearly to the conclusion that there is fundamentally new physics in the energy range just beyond the reach of existing colliders. At the very least we will find one or more Higgs scalar bosons or other structure that has the same effect as a Higgs boson on the existing data. To explore and characterize fully the new physics that must exist will require the Large Hadron Collider plus an electron-positron collider with energy in the TeV range. Just as our present understanding of the physics at the highest energy depends critically on combining results from LEP, SLC, and the Tevatron, a full understanding of new physics seen in the future will need both types of high-energy probes.

Major laboratories around the world are presently conducting accelerator research and development that will lead to detailed designs of a linear electron-positron collider capable of reaching this energy range. The technology being developed for this purpose will also have applications to other areas of science and technology through new generations of intense light sources. A worldwide group is studying the physics at an electron-positron collider and the detectors needed to observe that physics.

ICFA recommends continued vigorous pursuit of the accelerator research and development on a linear collider in the TeV energy range, with the goal of having designs complete with reliable cost estimates in a few years. We believe that an electron-positron collider optimized for the new physics should be built in a timely way with international participation.

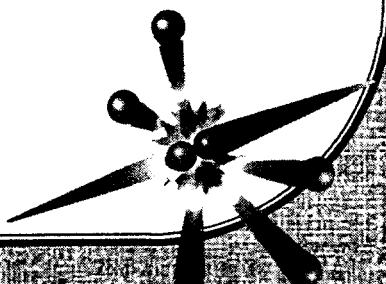


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# NLC

## National Effort

- Initial \$8B cost estimate of May 1999 was more than the International Community can afford —  $\leq \$5B$  with the host nation fronting 60% of the cost is probably achievable
- Strong NLC R&D National Program involving SLAC, FNAL, LBNL, LLNL
- Considerable progress in R&D program in past year. Increasing confidence that present design is intrinsically more tolerant of emittance preservation. Major improvements in RF power generation and distribution
  - now envisage  $\simeq$  factor of 4 higher  $\mathcal{L}$  with X band approach
- Strong focus on Design / Parameter changes aimed at reducing cost:
  - this process has yielded a lot of success. Clear opportunities to reduce May 99 cost by  $\sim 1/3$  without loss of scope
  - Range of options are being studied regarding the balance between the initial investment at 500 GeV and the upgrade path



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# Parameters for 500 GeV and 1 TeV



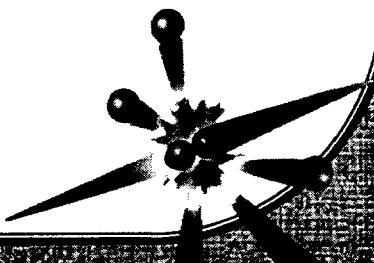
	IP Parameters for the JLC / NLC (2/24/00)			1 TeV		
	500 GeV			1 TeV		
	A	B	C	A	B	C
<b>CMS Energy (GeV)</b>	510	500	482	1022	1000	964
<b>Luminosity (<math>10^{33}</math>)</b>	5.3	5.4	5.5	10.6	10.8	11
<b>Repetition Rate (Hz)</b>	120	120	120	120	120	120
<b>Bunch Charge (<math>10^{-10}</math>)</b>	0.7	0.82	1	0.7	0.82	1
Bunches/RF Pulse	95	95	95	95	95	95
Bunch Separation (ns)	2.8	2.8	2.8	2.8	2.8	2.8
<b>Eff. Gradient (MV/m)</b>	58.7	57.3	55.2	57.3	55.2	55.2
Injected $\gamma \varepsilon_x / \gamma \varepsilon_y (10^{-8})$	300/3	300/3	300/3	300/3	300/3	300/3
$\gamma \varepsilon_x$ at IP ( $10^{-8}$ m-rad)	400	450	500	400	450	500
$\gamma \varepsilon_y$ at IP ( $10^{-8}$ m-rad)	6.5	8.5	12	6.5	8.5	12
$\beta_x / \beta_y$ at IP (mm)	12/0.12	12/0.12	13/0.15	12/0.12	12/0.15	13/0.15
$\sigma_x / \sigma_y$ at IP (nm)	340/4.0	330/4.6	365/6.2	220/2.8	235/3.2	260/4.4
$\sigma_z$ at IP (um)	90	120	140	90	120	140
$\chi_{ave}$	0.11	0.09	0.08	0.12	0.25	0.23
Pinch Enhancement	1.46	1.35	1.39	1.35	1.35	1.39
Beamstrahlung $\delta B$ (%)	3.2	3	3	3	8.1	8.4
Photons per e+/e-	0.86	0.96	1.05	2	1.25	1.38
Two Linac Length (km)	5	5	5	9.9	9.9	9.9

## **NLC National Effort (Continued)**

- **SLAC - primarily Ron Ruth and John Irwin - have made impressive strides using the two beam approach.**

**These ideas will be drawn into the core effort since it looks so promising to use the two-beam approach as the upgrade to multi-TeV collisions**

- **SLAC (with FNAL) is providing funding for user community to do Physics Studies.**



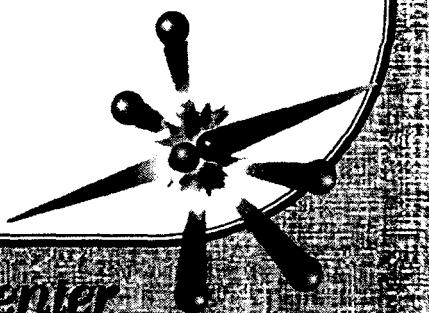
# **How is SLAC Participating in Long Term Development?**

**(Continued)**

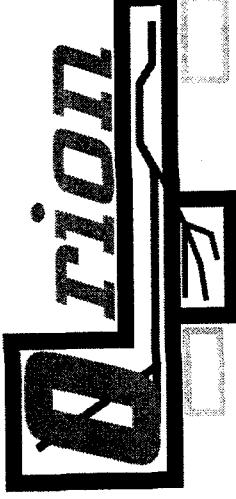
## **B) Generic Advanced Accelerator R&D**

- Crucial for the future of accelerator based science that we continue to support advanced accelerator R&D
  - push past the envelope of current methods
- University community is encouraged to join and lead such efforts. We see increasing user involvement at SLAC
  - ↳ exciting theoretical and experimental program at SLAC in the general areas of High frequency / High gradient acceleration, ultra-low emittance, plasma based devices, laser acceleration, two-beam acceleration...
- We are seeking support to establish a facility for a user-based, peer-reviewed program in advanced accelerator R&D

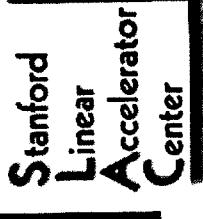
**Facility is called ORION**



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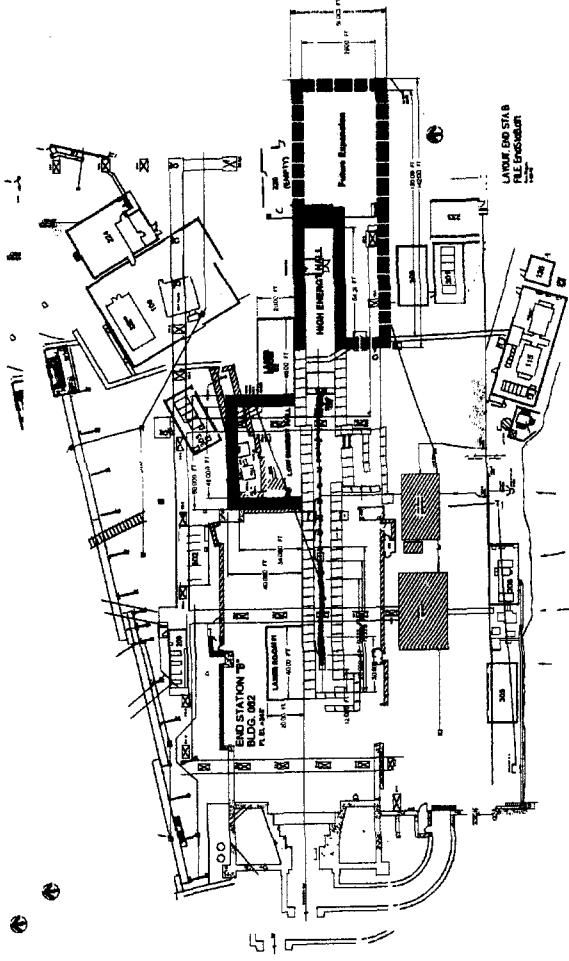


## Introduction



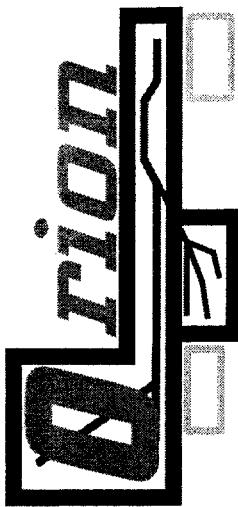
Advanced accelerator research is crucial for the future of particle physics.

Success will depend on many factors including involvement of scientists inside and outside the traditional accelerator physics community, university faculty and students, and facilities and resources of the national laboratories.

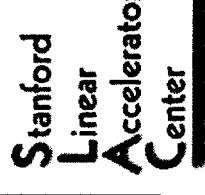


## ORION

- A user facility that would attract scientists with a passion for advanced accelerator research.
- A facility where the resources needed for that research are readily available.
- The accelerator, beamlines, instrumentation, etc. are available and user friendly so that physicists & engineers can concentrate on the physics and technology of future accelerators.
- I would like to see it develop a critical mass and become a focus for advanced accelerator research.



## Introduction



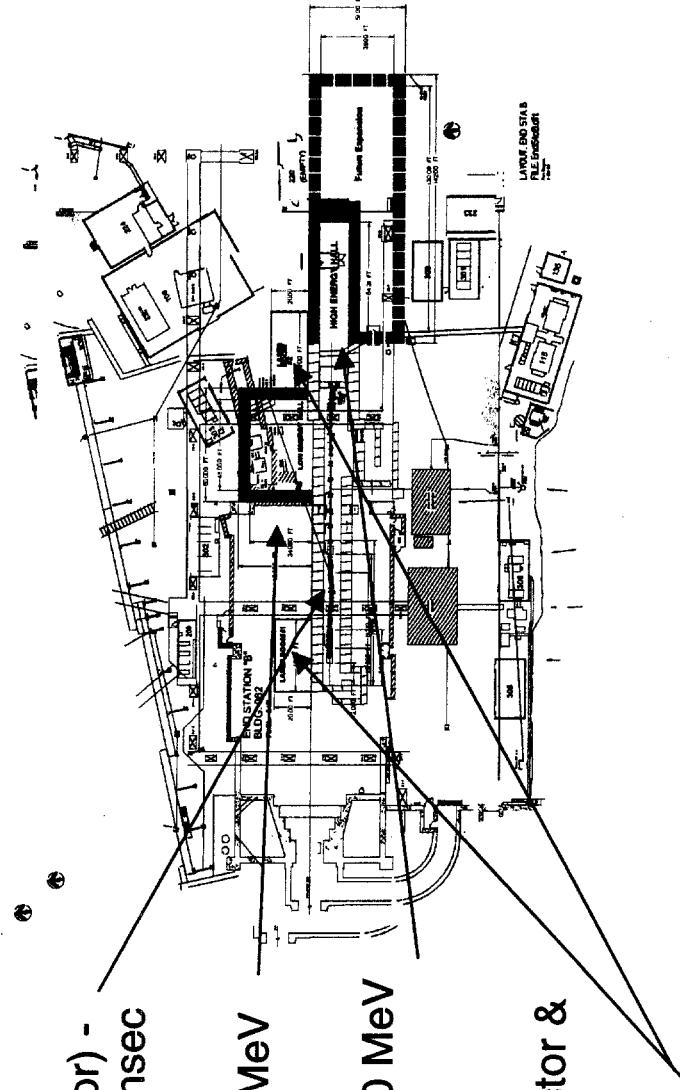
Based on the NLCTA (NLC Test Accelerator) -  
300 MeV, 11.4 GHz linac with a ~ 200 nsec  
long beam with X-band bunches

Low Energy Hall for experiments with ~50 MeV  
beam available most of the time

High Energy Hall for experiments with ~300 MeV  
beam that would have to be scheduled  
together with NLC RF development

Two injectors - the present long-pulse injector &  
a single bunch, RF gun

Two laser rooms for RF gun laser and  
experimental laser

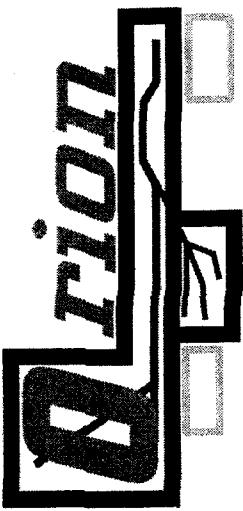


## Brief History

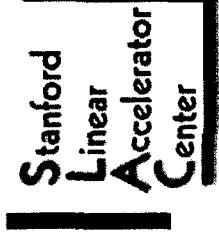
Study initiated in April '99 & completed in  
October '99  
Workshop in February '00

Reviewed & endorsed by DOE at SLAC's annual  
review, by SLAC faculty & SLAC Scientific Policy  
Committee

Now part of the SLAC program



# The ORION Workshop



## ORION Workshop

February 23 - 25, 2000

Chairs: Chan Joshi & Bob Siemann

Program Coordination: Dennis Palmer

Working Groups

High Gradient RF & RF Power Production    Hans Braun (CERN)

Plasma Acceleration    Tom Kaisouleas (USC)

Laser driven Accelerators and Structures    Ilan Ben-Zvi (BNL)

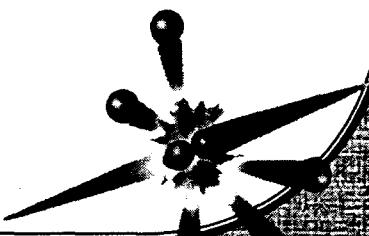
Particle & Radiation Sources    Jamie Rosenzweig (UCLA)

This was an important workshop for the ORION project

- It was the first opportunity for the advanced accelerator community to learn about ORION
- SLAC could gauge potential interest ~ 80 people attended
- Possible experiments were discussed
- Significant issues were identified

# Conclusions

- **The hallmark of SLAC for the past 40 years has been an acute sense of adventure:**
  - electrons have proven to be a spectacular probe of nature's secrets
  - wide range of technical innovation in both accelerators and detectors
- **SLAC will carry the same spirit of adventure into the new millennium:**
  - asymmetric collisions at  $> 10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$
  - lead role in realization of a TeV electron positron collider
  - new horizons in astro-physics, cosmology
  - angstrom sized coherent Xrays
  - advanced accelerator R&D
  - surprises - it's the things we haven't thought of that will likely turn heads



# **Conclusions**

## **(continued)**

- **Users will be key to maintaining a vibrant laboratory**
- **Collaboration is increasingly crucial**
  - interlaboratory
  - interagency
  - international
- **We have a very exciting near-term HEP program in the US. We must find ways to better articulate the excitement to our fellow scientists outside of HEP, to the Administration, and to Congress. Financial support for the program is reaching sub-critical levels**
- **The World HEP program cannot remain vibrant in the long term without strong leadership from the US program. Any long range World plan will require a future frontier machine hosted by the US**

